

form of control system a building is divided into areas or zones such that the general requirements and the general conditions through the areas are relatively constant as to exposure and occupancy, and then each zone is provided with control equipment which functions to regulate the conditions in that particular zone. As in the case of individual room control, each zone may be regulated to its own needs which may vary from the needs of other zones within the same structure.

The number of zones to be used is determined by several factors, such as:

1. Size of building.
2. Number and character of exposures.
3. Variation in occupancy or other inside conditions.
4. Cost of additional zones.

The greater the number of zones, the closer is the approach to the results and cost of individual room control. However, zone control has advantages even where individual room control is installed as it lightens the work of the room control. With room control, fewer zones are needed. In buildings of large floor area, it is usually desirable to have a separate zone for each exposure. If one wall is protected by an abutting building for half its height, two zones may be necessary. First floor conditions may vary enough from those of the rest of the building to justify a separate zone. In large buildings with several exposures toward any compass point, as occurs in wings and courts, all the northern exposures, for example, may be put on one zone control, or each north wall may have its own control. Court exposures are apt to be affected by surrounding walls and thus to require separate treatment.

In high buildings it is often important to consider zoning for stack or chimney effect in winter, caused by the difference in density between the warm air on the inside of a building and the colder air on the outside. Where the lower eight or ten stories are protected from winds by surrounding buildings, it may accentuate the need for zoning to correct the chimney effect, and on windy days there will be a marked difference in the heat requirements for the different horizontal sections at different elevations. An arrangement to provide for difference in heat requirement for exposure and chimney effect would give 12 zones; namely, north, east, south, and west, lower, middle and top zones.

For steam heating systems the automatic control arrangement varies with the means of obtaining reduced temperatures. Some of the methods in common use are described in Chapter 14. From the control standpoint they are classified as follows:

1. Throttling steam to allow flow in proportion to the needs for heating.
2. Turning the steam on and off, leaving it on for longer or shorter periods as required.
3. Varying the pressure differential between supply and return lines, and varying the absolute pressures in both, so as to change the amount of steam passing through the radiators, due to the differences in pressure drop and due to the differences in volume per pound of steam.

The controlling thermostats may be inside or outside instruments or a combination of the two. Ordinary inside thermostats alone are likely to give disappointing results because an unusual condition at the thermostat upsets the whole zone, and because a slight temperature drop may allow

too much steam to pass before its heating effect reaches the thermostat. Therefore some device is needed to vary the flow in accordance with the weather. This may be a simple long range thermostat that restricts the flow as the weather moderates, or one that turns the steam off and on, on oftener and for longer periods in cold weather. One device is designed to directly control radiator temperatures at progressively lower points as the weather becomes warmer. Most outside thermostats have provision for sun and wind effect. They do not produce close control of indoor temperature, and are usually accompanied by hand switching devices for raising and lowering the control point, where individual room control is not included. They are, as stated previously, valuable adjuncts of room control.

For a hot water heating system, zone control consists of an outdoor thermostat varying the temperature of the water in accordance with the weather. This may be done by changing the amount of heat applied to the water, or by mixing hot water with recirculated water so as to produce the proper temperature. Inside zone thermostats may be used to correct improper action of weather thermostats, or, where only one outside instrument is used for a number of zones, to start and stop circulating pumps in accordance with the demand for heat in the various zones.

For both steam and hot water systems, zone control is primarily to reduce the general heating effect in moderate weather. Thus the term is used to describe a type of control system, though a building may have but a single zone.

In air conditioning systems, zone control may be applied to separate fan systems in different parts of a building or to two or more sections of the air distributing system from a single fan. The zone thermostat may be room type, or insertion type located in the return air duct from the zone. Where each zone has its own fan, the control may be the same as for an independent system. If one fan serves more than one zone, there will be heating and cooling coils for each, or a damper to mix air volumes of two temperatures to provide the proper conditions for the zone.

Zone control for an all-year air conditioning system presents problems that do not arise in either the heating or the cooling cycle alone. As a zone is normally selected for similarity of conditions, and the distribution of temperature effect to the various rooms adjusted so that one control point is sufficient, it is important that the similarity of conditions applies equally to heating and cooling. Two rooms that have like heating loads and that work well together in the heating season, may have entirely different cooling loads. This difficulty can be overcome by the use of sub-zones or individual room control where necessary.

CENTRAL FAN SYSTEMS

Central systems for air conditioning are described in Chapter 21. For explanation of the control problems for such systems, the various functions, such as heating, humidification, and cooling, are treated independently.

Ventilating Systems

A control system for a central fan ventilating system using all outdoor air and discharging air at a predetermined temperature is illustrated in

Fig. 2. Thermostat T_1 located in the outdoor air intake is set just above freezing, and controls valve V_1 on the first heating coil. This arrangement, where the valve is held completely open or closed to avoid danger of freezing, must be used where the coil is not specially designed for uniform steam distribution across its face. The by-pass damper around the heaters and the other two valves V_2 and V_3 are controlled by thermostat T_2 located in the discharge duct from the fan. When the temperature of the discharge air is too high, T_2 closes V_3 and V_2 , gradually and in sequence, then if V_1 is open and supplying too much heat, T_2 opens the by-pass damper. The control of the damper and valves V_2 and V_3 must be gradual to prevent wide fluctuation in temperature.

In ventilating systems it is customary to supply air to the ventilated spaces at an inlet temperature approximately equal to the temperature maintained in the rooms. The radiators therefore are designed to take care of all the heat losses from the rooms and in order to maintain controlled room temperatures it is necessary to control the radiators independently of the ventilation control.

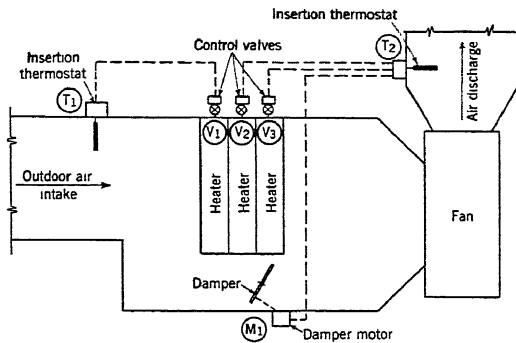


FIG. 2. CONTROL OF A CENTRAL SYSTEM FOR VENTILATION

In central fan systems, air washers are sometimes used and in such cases, due to the effect of temperatures on humidity, additional control is required. The heating coils are then divided, one or two at the inlet and usually two at the outlet, generally called preheaters and reheaters. There should be no by-pass under the former, because of the danger of a stratum of cold air freezing the water. To maintain relative humidity at a constant point a dew-point thermostat is inserted into the air stream between the two sets of coils, to control the preheaters. Cold air control of preheaters cannot be used because at temperatures just below freezing a standard heating coil, which will protect an air washer against freezing in zero weather, will give a too high dew-point temperature. Therefore, the one or two preheater coils must be controlled from the dew-point thermostat. This is preferably placed at the discharge side of the washer and set for about 40 or 45 F. As there is some cooling effect from the water, this provides a slightly higher temperature leaving the coils. In such cases, the throttled steam must be fairly uniformly distributed across the face of the coil, to prevent a stratum of cold air that would freeze water in the coil or in the washer.

Heating Cycle

Similar fan systems are used for heating, as well as for ventilating occupied spaces, by increasing the number of coils to four or five. Where they are all installed together the control remains the same as shown in Fig. 2, and the additional coils are controlled directly from a room thermostat which also causes T_2 to turn on full heat while the room is cool, but to function as described previously while the room is warm. This facilitates rapid heating of the room, after a vacant period.

An alternate plan is the use of a fan discharge thermostat whose control point can be automatically varied, and a room thermostat to reset it. Thus when the room is cold, air is delivered at a maximum temperature designed for rapid heating, and when the room is too warm, the air is kept as cool as can be safely introduced, or as the weather permits. The discharge temperature varies between these two extremes at the command of the room thermostat, until it finds the proper point for the existing conditions. This makes it unnecessary to vary the fan discharge thermostat manually to prevent overheating in moderate weather, or chilling in cold weather.

The heating coils are often separated into two groups, one at the suction side of the fan, controlled as shown in Fig. 2, and the other on the down stream side of T_2 , controlled from the room. Control T_2 is then called the *tempered air* thermostat.

In all types of fan heating systems it is desirable to have the tempered air thermostat in the fan discharge where stratification has been broken up by the fan.

Where a fan system supplies heat to several rooms or zones that require separate treatment, the tempered air control can remain as in Fig. 2, and the variation can be supplied in any of the following ways:

1. By installing a separate duct to each zone, and using individual heating coils, each under control of its respective room thermostat.
2. By installing double chambers at the fan discharge, only one of which is supplied with additional heating coils. Individual room or zone ducts have mixing dampers which allow air to be taken from the warm air chamber, the tempered air chamber, or both, as demanded by their respective room thermostats. With this arrangement, precautions must be taken to prevent the warm air from being churned back and into the tempered air while a number of the mixing dampers are calling for the latter. If the warm air is controlled at a constant temperature under all conditions, the coils should be placed not less than 8 ft from the fan discharge and the dividing plate extended back several feet toward the fan. A good solution for the problem is to use an automatically adjusted thermostat in the warm air chamber, controlled by an outdoor thermostat so as to carry maximum warm air temperatures in the coldest weather and minimum in moderate weather.
3. By using a trunk duct, and varying the amounts of air delivered, by dampers at individual outlets or for the various zones. If a minimum amount of air is required for ventilation, the dampers must not close entirely. Thus to prevent over-heating, the trunk duct temperature must be varied according to the weather, as previously described. Also static pressure control may be needed. See a subsequent sub-head for a more detailed discussion of this subject.

Case 1 is illustrated in Fig. 3. Thermostat T in the fan discharge controls outside and return air through damper motors D_1 and D_2 , face and by-pass dampers through damper motor D_3 and the steam supply to a heating coil through valve V_1 . By having the face damper closed, and

the by-pass open, before steam is throttled, there can be no danger of freezing the coil. Thus the D_3 operation is completed before V_1 starts. However, the relationship between D_1 and D_2 controlling the amount of recirculation, and D_3 regulating the amount of steam heat added, depends on the design of the ventilation system. If the maximum amount of outside air is desired for ventilation, and return air is used only when insufficient steam is available, D_1 and D_2 operate to bring in all outside air before D_3 starts. On the other hand if greatest heating economy is desired and full outside air is to be used only to prevent overheating, D_3 completes its motion to close the face damper, before D_1 and D_2 start. Any relationship can be attained between these two extremes. Relay R prevents T from closing the outside damper completely, when a minimum of outdoor air is required during operation. Valves V_2 and V_3 control the steam supplied to booster coils for two zones, in accordance with the

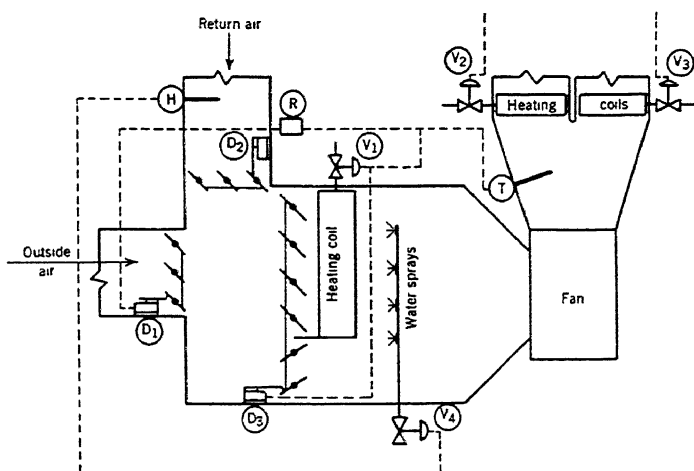


FIG. 3. CONTROL OF A CENTRAL SYSTEM FOR HEATING AND HUMIDIFICATION

requirements of room type zone thermostats, not shown in the diagram. Humidistat H , in the return air, regulates the amount of water supplied through V_4 to the spray heads.

Humidification

Humidification with air washers has been mentioned in connection with control of ventilating systems. Where ample room air change is provided, it is generally assumed that the dew-point of the conditioned space will soon equal that of the delivered air. This is due to exterior walls, especially glass, being less pervious to vapor flow than to heat transmission. With partial recirculation, dew-point control prevents over- as well as under-humidification, for ordinary installations.

Where air washers are not used, humidification may be accomplished by water sprays, preferably with heated water; by steam heated water in pans; or by steam jets, if their odors are not objectionable. Sub-atmospheric steam cannot be used, of course, for jets, and is not of much more value in coil heated pans. In all these cases the control is obtained by

humidistats, usually placed in rooms or in return air ducts. In ventilating systems the controlling instruments may be put in the fan discharge for results comparable with dew-point control. However, as hygroscopic elements are actuated by relative humidity they cannot be used with discharge temperatures that have been raised to supply heating effect.

Humidity control in cold weather is complicated by the danger of causing condensation or frost on windows and exterior walls, when otherwise desirable relative humidities are obtained. For satisfactory results in buildings that are not specially designed to prevent cold interior wall and glass surfaces, it is necessary to maintain lower humidities in very cold weather. This is done automatically either by an auxiliary humidistat mounted at a window to prevent condensation at that point, or by using a type of room or duct humidistat that is reset by an outdoor thermostat to maintain gradually drier conditions as the weather gets colder.

Cooling Cycle

Although central systems are occasionally used for cooling and dehumidifying only, the control features are essentially the same as for complete air conditioning systems. Where control of room conditions is obtained by varying the quantity of cooled air, as in a trunk duct system, individual room or zone thermostats operate volume dampers. It is customary to have these installed with a stop to prevent shutting off the air supply entirely, the reduction being from 40 to 60 per cent of the maximum delivery, depending on the design of the system. Later described control of the temperature of the air prevents over-cooling with the minimum supply, and the damper variation is normally sufficient to handle the distribution of the cooling effect throughout the area supplied by the fan or trunk duct.

In cases where systems and outlets are designed for particular velocities for proper room diffusion, volume dampers tend to produce undesirable results, by changing these velocities. Partially closed dampers reduce volumes in their ducts and increase volumes elsewhere. Trouble from too little air can be reduced by having the dampers close off, in one way or another, a part of the grille openings, thus maintaining approximately the same velocity through a smaller grille area. Trouble from increase of static pressure, due to reducing air volumes delivered, can be corrected by static pressure control, as described under a separate subheading in this chapter.

In installations where constant volumes of air are desired, and individual ducts are run to each room or zone, as shown in Figs. 3 and 5, of Chapter 21, air temperatures are varied as for the heating cycle, by room thermostats operating (1) mixing dampers which take air from either or both of two chambers, one of which has been cooled to the minimum temperature ever required; (2) booster cooling coils, one for each duct, in which the refrigerating medium can be turned on or off, or modulated; (3) individual by-pass dampers around booster cooling coils which are kept at a constant temperature; or (4) reheating coils which in times of light cooling load add heat to air that has been cooled to the minimum temperature required.

All these arrangements apply where one fan supplies more than one

room, or zone, and consequently the temperature-varying devices are downstream from the fan. The remainder of the control for the system is concerned with maintenance of conditions at the fan and is similar to what is used where a fan system is treated as a single zone.

Air washer cooling and dehumidification is commonly controlled by pumping the spray water through, or around a water cooler, with a dew-point thermostat operating a mixing valve which regulates the amount of water by-passing the cooler. An alternate scheme is to put cooling coils in the air washer spray or the pan, and to control the temperature of the coil. In both cases control of relative humidity is obtained by maintaining a constant dew-point temperature and thus a constant amount of water vapor per cubic foot of air handled. On account of this humidity factor, air leaving the washer must be reheated. As explained in Chapter 21, this is done, (1) by passing uncooled air around the washer¹ with thermostatic control of the proportion of uncooled air; (2) by adding heat by means of an automatically controlled coil; or (3) by allowing the room air to provide the heat by diffusion, in which case, still assuming a constant volume of air, the only means of dry-bulb control is the raising and lowering of the dew-point temperature, and hence the relative humidity.

Heat transfer surface coils, now more frequently used for cooling and dehumidification, are of either the direct expansion or cold water type. The former may be controlled by starting and stopping or unloading the compressor, by opening and closing a valve in the liquid line, by throttling the expansion valve, by throttling the suction line, or by raising and lowering the coil pressure, and temperature, through operation of a back pressure valve. The cold water type coils are controlled by valves to regulate the flow of water. They may throttle the flow, or they may be of the three-way type that allows a uniform flow but by-passes any necessary amount around the coil. Where well water pumps are operated only for cooling coils, control is added to stop them while cooling is not needed, but if they serve other purposes, they continue to run and the water is controlled by throttling valves.

The control with all types of coils may include a damper in an air by-pass² around the coils, with or without one over the face of the coils. If the installation is large enough to justify the use of two or more coils, side by side, the special air by-pass may be omitted and similar results obtained by closing the coils in sequence. The controlling instrument in all these cases is a thermostat in the room, return air, or fan discharge, whether the system serves one zone or several. In the latter case, a thermostat in the return air or in the fan discharge serves as a primary control, and the final control of room conditions is obtained with the zone thermostats.

Room or zone control in the cooling cycle is commonly provided by thermostats which operate at varying points depending on the weather. This takes care of the difference in optimum temperatures for the heating and cooling seasons and also of the objection to maintaining too high a differential between indoor and outdoor temperatures in hot weather.

¹Patents exist covering the by-pass method.

²Loc. Cit. Note 1.

A thermostat sensing outdoor conditions is used to reset inside temperatures, raising them gradually to a point from 5 to 15 F below the highest outside temperature. This differential depends on the type of occupancy. Temperatures should be maintained so as to avoid too great a change for anyone entering or leaving. In large buildings, gradually lower temperatures at increasing distances from entrances and exits can be arranged. See Chapter 2 for general remarks about proper temperatures.

Except in the case of dehydrating systems, independent humidistatic control of dehumidification is seldom provided. Air washer systems as already described, are provided with dew-point thermostats. Cooling coils may be designed for proper proportion of sensible and latent heat removal so as to give satisfactory relative humidity when only the temperature is controlled. For a small installation, without by-pass or other reheat, a room thermostat and humidistat are sometimes arranged to provide cooling until both the temperature and humidity requirements

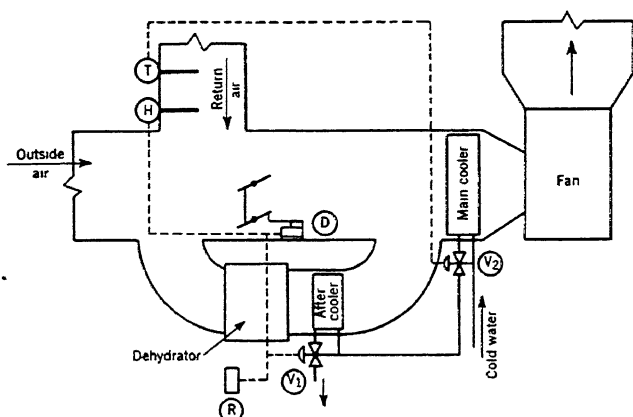


FIG. 4. CONTROL FOR A DEHYDRATING AND COOLING SYSTEM

have been satisfied, and a second thermostat is used to prevent excessive cooling by the humidistat. The cooling may be regulated by a combination of temperature and humidity that approaches *effective* temperature, by causing the relative humidity to gradually readjust the temperature control point, higher for dry air.

Control of Refrigeration. Room or duct conditions may start, stop and *unload* the refrigerant compressors directly, or may operate only at the evaporators. In either case other controlling instruments are used for the refrigeration, as described under the general heading, Control of Refrigeration Equipment.

Control of Direct Dehumidifiers—Dehydrators. Absorbent and adsorbent types of conditioning systems have the dehumidification controlled by room or return air humidistats. Since these processes are capable of producing relative humidities much below the desired point, only a portion of the air may be treated and a by-pass damper, controlled by the humidistat, used to vary this portion. The control of water cooling coils is similar to that previously described, except that the additional coil, used to extract

the sensible heat transformed from latent by the process, can use cooling water leaving another coil. That is, water leaves the main cooling coils at a low enough temperature to do the requisite cooling for the high temperature air. In order to have water available at both coils, the control valves at each are of the three-way type. As this allows free flow of water at all times, a normally closed valve can be installed in the water line and controlled by a thermostat varying the flow to maintain a suitable temperature. By connection to the fan motor circuit the valve can be kept closed while the system is not in use.

Some of these features are shown in Fig. 4. Humidistat H , on rising humidity, simultaneously starts the dehydrator and its fan through relay R , positions three-way valve V_1 to permit water to flow through the aftercooler, and closes damper D to increase the resistance in the main duct so as to reduce any tendency of the dehydrated air to short-circuit. Outside air and return air dampers, commonly used, are not shown. Their operation is as described for Fig. 3, except that for the summer cycle, the outside air is fully opened before V_2 turns on the main cooling

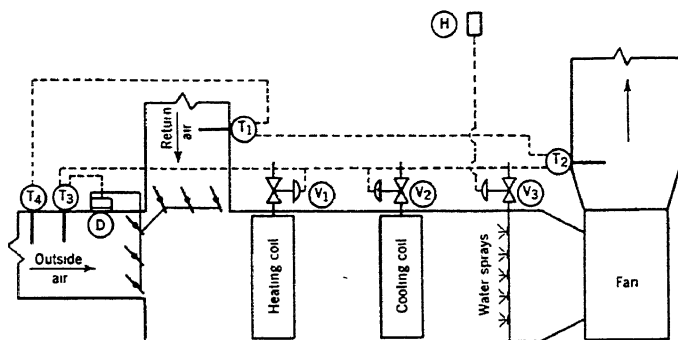


FIG. 5. CONTROL FOR AN ALL YEAR CENTRAL SYSTEM

coil, and a wet-bulb or similar thermostat in the intake cuts the outdoor air to a minimum when its wet-bulb temperature is greater than that of the return air.

All Year Systems

All year systems combine the features described for heating and cooling cycles, and have provisions for spring and fall conditions. Complete automatic control of all year systems incorporates an automatic change-over between the cooling and heating cycles. If the installation necessitates operation of a manual switch or other change-over device between the heating and cooling cycles, then the control system is semi-automatic. The full automatic change-over between cycles becomes particularly desirable in the early and late portions of the cooling and heating seasons, when heating and cooling may be required alternately.

For all year systems, a single thermostat may be used for both heating and cooling cycles, as shown in Fig. 5. In this diagram, T_2 regulates the amount of recirculation through damper motor D , the amount of steam by valve V_1 and the amount of chilled water by V_2 . As the temperature rises, V_1 first operates completely to close off the steam; next, outdoor air

quantities are increased from a minimum, if the outdoor temperature as sensed by T_3 is low enough to provide cooling; and finally chilled water valve V_2 opens. Control T_2 , however, operates, not at a constant temperature, but at a point varying from the minimum required in warm weather to the maximum required for heating. The variation is effected by T_1 in the return air, which raises and lowers the control point of T_2 until the proper return air temperature is obtained. During the heating and intermediate seasons, T_1 operates at a constant point, but in the cooling season it is readjusted by outdoor air thermostat T_4 to provide higher indoor temperatures. Room humidistat H opens valve V_3 on falling humidity to turn on the water sprays. As inside humidities in summer are normally higher than required in winter, the sprays are automatically kept closed.

Several diagrams of large central systems are shown in Chapter 21. The arrangement of cooling coils diagrammed in Fig. 2 requires control similar to that just described, except that if the cooling coil is of the direct expansion type, the refrigeration is controlled as explained in this chapter under

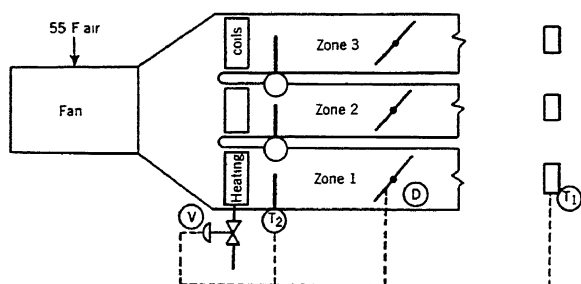


FIG. 6. ALL YEAR ZONE CONTROL WITH BOOSTER HEATING COILS AND VOLUME DAMPERS

Cooling Cycle. In Fig. 3, a dew-point thermostat near the eliminator plates, on a rising temperature first turns off the preheater and then turns on the water cooler. A return air or fan discharge thermostat controls the reheater coil, and the return air and by-pass dampers. Assuming that the coil is not heated in summer, the by-pass damper is opened and the return air damper closed to provide reheat. In winter, provision must be made to keep the by-pass damper closed, or to reverse its operation to prevent by-passing the coil when heat is required.

The temperature at the primary fan in Fig. 7 is maintained 10 F or more below desired zone temperatures throughout the year, to allow correction of overheating in winter. In summer this setting is further reduced, to cut down the amount of outside air required for cooling and to provide sufficient dehumidification. The zone thermostats thus call for more return air for reheat.

Where the internal cooling load is great, an arrangement as shown in Fig. 6, of this chapter, has some advantages. Air entering the fan is controlled at about 55 F by operation of a steam valve and outside and return air dampers, so long as weather permits. In summer the refrigeration is turned on at a somewhat higher temperature, as required. Booster heating coils, low limit thermostats, volume dampers and room,

or return air, thermostats are installed for all zones, as shown. Volume dampers are adjusted with a minimum position that will supply sufficient air quantities for heating. While a zone is too cold, T_1 holds D in minimum position and steam valve V wide open. On rising zone temperature, the steam is first gradually turned off, and if internal heat sources cause the temperature to build up, D gradually opens to increase the amount of cool air delivered. Control T_2 is set for the minimum temperature at which air can be introduced into its zone.

If heating as well as cooling is supplied only by the fan system, and zone control is by volume dampers, special instruments known as *summer-winter* thermostats are required to open the dampers on falling temperature in winter and on rising temperature in summer. Such instruments are also used similarly to operate valves which supply hot water in winter and chilled water in summer.

Economizer Controls. Although the saving of fuel or power is one of the reasons for using any automatic control equipment, there are some applications where this is the sole reason. For example, central fan systems are usually designed to use all outdoor air, or as much as required, while it has suitable characteristics, for economical operation. Except for cases such as chemical laboratories where return air cannot be economically used, dampers are placed in both the return air and outdoor air ducts to regulate the amount of air used from each. These may or may not be mechanically interconnected but are arranged so that as one opens the other closes. Where a minimum amount of outdoor air is needed for ventilation requirements, the control of dampers may include a relay to prevent closing the outdoor damper beyond a certain adjustable point or this damper may be divided into two sections, only one of which operates with the return air damper. Another relay connected to the fan motor circuit operates the minimum outdoor opening, in either case, as the fan is started and stopped. Usually it also places the remainder of the dampers in recirculating position when the fan stops and leaves them under control of their thermostats while the fan is running.

The control of recirculation is from thermostats. Since the outdoor air, in excess of the minimum required for ventilation, is used for cooling, the dampers are commonly interconnected with other cooling devices, so as to gradually increase the amount of outdoor air, and no refrigeration is turned on until the possibilities of natural cooling are exhausted. So long as the wet-bulb temperature outside is lower than that inside the more outdoor air used during the cooling cycle, the lower the operating cost. However, as soon as the wet-bulb temperature of the outdoor air exceeds that inside, its use should be reduced to the minimum. This is done automatically by the conditions of the outdoor air as sensed by:

1. A wet-bulb thermostat.
2. A dry-bulb thermostat readjusted by a humidistat to produce operation approaching wet-bulb control.
3. A dry-bulb thermostat and a humidistat working together, either one of which may throw the dampers to recirculating position.
4. A dry-bulb thermostat, alone.

These items are listed in order of importance, from a theoretical standpoint, but practical considerations reverse the order. A wet-bulb ther-

mostat must be removed, or protected from damage, in sub-freezing weather. A dry-bulb thermostat is the most dependable under all conditions, and is generally sufficient for small installations. However, the considerably greater economy of wet-bulb or similar control justifies its use for the larger installations.

Limit Controls. There are certain limiting devices which are not concerned primarily with final room conditions but are necessary safety features. High and low limits for refrigeration pressures are described under Control of Refrigeration Equipment. Limit temperature controls are often used with heating coils exposed to sub-freezing air, to prevent freezing the condensate. Where there is danger of lack of steam pressure, a thermostat should be placed in the system to stop the fan or close the outdoor air damper when heat is not available.

The tempered air thermostat described under the Heating Cycle serves as a low limit for air introduced in winter. When cold outside air is used for cooling, this same thermostat is used to restrict the amount, while inside conditions call for full cooling. A low limit fan discharge thermostat is sometimes operated in conjunction with the refrigerating cycle, although this is usually unnecessary.

A thermostat can also be placed in the fan discharge to stop the fan in case of fire. The maximum temperature setting is often determined by local regulations, but the most protection comes from the lowest feasible setting and a point is recommended only a few degrees higher than the highest temperature of normal operation. Safety measures to prevent gravity as well as forced flow of air, in case of fire, often require various dampers throughout the fan distribution system to be closed by fusible links or by thermostats.

Static Pressure Control

As described and illustrated in Chapter 31, the discharge of air through outlets must be carefully studied for proper results. Control systems that depend upon varying the air quantities are apt to upset the design conditions. Even where the dampers are located so as to maintain proper outlet velocities, as well as possible, by closing off portions of the grilles, there is a general increase in static pressures when most of the dampers reach their minimum positions. This tends to defeat the operation of the damper and magnify the danger of noise.

Air filters, commonly used in central fan systems, vary the operating static pressure in two ways. Reduction of air quantity tends to reduce the static drop through them as through all other resistances to air flow, but accumulation of dust increases this static drop. Thus filters add to the need for static pressure control.

This control consists generally of a device operating one or more dampers. If filters are not used and the only function of the controller is to reduce high pressures caused by reduction in amounts of air delivered, the dampers may be in the side of the main duct downstream from the fan, and arranged for opening enough to relieve the excess pressure. In this case, if the controller is of the differential type, affected by ambient pressures, care must be used to prevent distortion due to slight building up of pressure in the room outside the duct.

Whether or not filters are used, dampers may be installed across the area of the duct on either side of the fan. One type is of special design for attachment to the fan intake. Closing such dampers reduces the pressure in the distribution ducts. When filters are used, the systems may be designed for operation with the dampers partially closed while the filters are clean, so the pressure controller can automatically open them to correct for the gradually increasing resistance caused by dust accumulation.

Air distribution systems designed for high velocities and consequent high pressure drops are not entirely corrected for action of volume dampers by static pressure control at the fan, because varying pressure drops through the ducts follow changes in quantities of air delivered. Therefore, where relatively constant pressures are important it may be necessary to use controllers at several carefully selected points.

Back pressure dampers, commonly used to prevent down drafts through vent flues, may be employed to relieve objectionable pressures in rooms or other spaces, under certain conditions.

UNIT SYSTEMS

A unit system provides for the same functions as a central fan system except that the actual conditioning is usually done within the space being conditioned instead of at some central location outside of the space. The automatic control problems, therefore, become exactly the same as for central fan conditioning systems except that compactness, ease of installation and control cost often assume somewhat more importance.

Because of the usual segregated location of unit equipment throughout a building and its consequent lack of competent supervision, complete automatic control is essential to its satisfactory operation.

Unit Heaters

In its simplest form, unit heater control consists of a room thermostat to start the unit heater motor when heat is required and shut it off when the demand is satisfied. With this limited control, it is possible in some instances that, with no steam available at the heater, the operation of the fan would cause objectionable drafts. To avoid this, limit controls are available which will prevent the operation of the fan at the command of the room thermostat except when steam is available, as determined by the temperature of the steam or return pipe or the pressure of the steam supply.

Where several unit heaters serve a limited area, they may be grouped for purposes of automatic control, and several heaters placed in operation at the command of one thermostat. By properly grouping the units which will operate together, the benefit of zone control can often be obtained with a minimum of control equipment. Where such group operation is utilized, the thermostat and limit control usually function through a relay, as the combined load of the several motors may exceed the current capacity of the thermostatic control device.

In some cases where cold drafts will not result, it is desirable to operate the unit heaters continuously for circulation of air. In such instances the

room thermostat regulates the supply of steam to the unit through a control valve in the steam supply line and the unit heater motor operation is manually controlled.

Unit heaters equipped with dampers arranged for by-passing air around the heating coils are controlled by room thermostats operating modulating damper motors attached to these dampers so that as the temperatures rise, a decreasing amount of air is heated. When the by-pass is wide open the heating effect is so much reduced that control of the steam supplied to the coil is not generally important. If valve control is added, the throttling of the steam may be concurrent with, or subsequent to, the opening of the by-pass.

Cooling Units

The recommended form of temperature control for a cooling unit contemplates the continuous operation of the fan, with automatic regulation of the compressor or cooling coil, or both, as determined by a thermostat in the room, or in the return air to the cooling unit. Such operation insures continuous circulation of air in the room, and in addition to providing the cooling effect of moving air, overcomes the tendency of the air to stratify. As the temperature begins to rise, the controller opens the valve to a cold water cooling coil, or for direct expansion coils, opens a valve in the refrigerant line, closes a by-pass around the coil or starts a compressor.

Cooling units may also be controlled by arranging the room thermostats to start and stop the fan motors or by a combination of motor and refrigerant control.

Unit Ventilators

There are various types of unit ventilators available but in general all types are designed to draw air from the outside or to mix outside and recirculated air, heat it and introduce it into the room under control of a thermostat.

The design of unit ventilators has to an extent been based on the requirements for automatic temperature control and the cycles of control have been developed to include other heating devices in the rooms with unit ventilators. Unit ventilators are frequently used in schools and other types of buildings where many states have laws or regulations governing the minimum amount of ventilation to be provided. The control of the amount of outdoor and recirculated air is designed to conform to the various laws. Usually the device circulates a constant amount of air and the amount automatically taken in from outdoors is controlled in one of these ways:

1. Full recirculation until the room temperature reaches a certain point, generally two degrees, below the desired room temperature; then a minimum amount of outdoor air for ventilation while the temperature is maintained by throttling steam; and if the room temperature rises with all steam shut off, the gradual increase in amount of outdoor air up to 100 per cent.
2. Full recirculation until the room reaches a set point below room temperature, after which all air is taken from outside.
3. Gravity recirculation while the fan motor is not running, with full outside air as soon as the fan starts, obtained by a relay in the motor circuit.

4. Full recirculation or all outdoor air as determined by a manual switch which can be operated at any time whether or not the fan is running. All the unit ventilators in a single building may be operated by one or many switches.

With arrangements 1 or 2, it is desirable to include a relay to prevent the intake dampers from opening while the fan is not running, regardless of room temperatures. With a dual system of control this is essential to prevent the thermostat keeping the outside damper open until the temperature falls to the reduced setting.

The intake and recirculated air quantities are determined by a single damper or by a pair of dampers working together, and operated by a damper motor. Although this affects the temperature of the air delivered, the main heat control comes from the throttling of the steam supplied to the heating coil, with or without by-pass damper control. To prevent air being delivered at too low a temperature, a low limit thermostat is commonly installed in the air stream and set at some point between 55 and 70 F. The lower settings may cause discomfort, the higher ones overheating, depending on circumstances. The air stream thermostat can be used to turn on steam, reduce the amount of outside air, or both.

Rooms with unit ventilators frequently have auxiliary heating devices, such as direct radiators, convectors or unit heaters, all under control of a single room thermostat. A common control cycle for such rooms is composed of the following functions, assuming that 72 F is the desired temperature:

1. Below 70 F the unit ventilator intake damper is in full recirculating position and all heat is turned on.
2. At 70 F the intake damper moves to a position that will admit a predetermined minimum amount of air from outdoors.
3. At 71 F the auxiliary heating devices are shut off.
4. From 71 to 72.5 F, the heating effect of the unit ventilator is throttled.
5. From 72.5 to 74 F, the intake damper is gradually moved to increase the amount of outside air from the set minimum to 100 per cent.
6. If the room thermostat calls for too much cooling, the air stream thermostat holds the delivery temperature at a proper minimum.

Other similar cycles may be used. One additional feature is the use of an air stream thermostat that has its control point reset by the room thermostat. Then as the room temperature rises, the delivery temperature is gradually reduced from a maximum to a minimum.

All Year Conditioning Units

It is desirable to provide for automatic change-over between the heating and cooling cycles in the control system for all year conditioning units because of the probable necessity of a change several times a year. In the fall season a period requiring cooling often follows one requiring heating, and the reverse is true in the spring. The automatic change-over is especially valuable where a large number of units is used.

A control system for an all year conditioning unit providing for the automatic change-over is shown in Fig. 7. Operation of the control equipment is as follows:

1. *During the Heating Cycle.* Combination controller T_1 measures the temperature in the space being conditioned and opens control valve V_2

so as to admit steam to the heating coil whenever heat is required so as to maintain a fixed temperature in the space. Combination controller T_1 also measures the relative humidity in the conditioned space and opens control valve V_1 so as to admit water to the sprays whenever moisture is required in the space.

2. *During the Cooling Cycle.* Combination controller T_2 measures the temperature and humidity in the conditioned space and opens refrigerant control valve V_3 , thereby admitting refrigerant to the cooling coil whenever cooling is required to maintain the temperature or relative humidity within predetermined maximum limits.

The temperature control point of controller T_1 must be set at a lower point than that of controller T_2 in order to provide for the automatic change-over between the cooling and heating cycles. As an example, controller T_1 might be set at 72 F and 35 per cent and T_2 at 76 F and 60 per cent. As the room conditions rise above the settings of T_1 , the

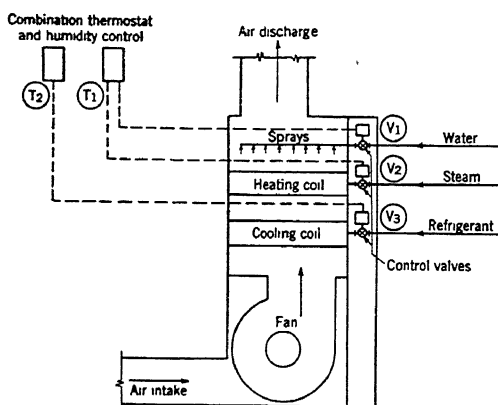


FIG. 7. ALL YEAR AIR CONDITIONING UNIT WITH COMPLETE AUTOMATIC CONTROL

heat and humidification are shut off and when they rise above the settings of T_2 the cooling and dehumidification are turned on.

CONTROL OF AUTOMATIC FUEL APPLIANCES

It is essential that automatic controls be used with oil burners, gas burners, and stokers in order to maintain even temperatures and provide safe and economical operation of the heating plant. There are many types of burners and many types of automatic control, and it is essential that the proper type of control equipment be selected to fulfill the requirements of the burner equipment and its application.

Combustion regulation equipment should be used on the larger commercial and industrial applications to control the secondary air supply and thereby provide for economical operation. This type of control will usually consist of a pressure regulator which measures and controls the pressure over the fire and which thereby indirectly regulates the carbon dioxide percentage in the flue gas.

On all automatically-fired steam boilers it is advisable to provide

control equipment which will stop the supply of fuel in case the boiler water line falls below a predetermined level of safety.

For hot water and warm air systems, control devices can be arranged to vary the water and air temperatures from outdoor thermostats. As the weather moderates, lower temperatures are maintained. Inside thermostats are usually installed to correct any improper results from the outside controls.

Thermostats used to control automatic fuel appliances may be supplied with clock mechanisms which will automatically shut off the heat or maintain lower temperatures during night hours for economy of fuel. For buildings that are not used every day of the week, clocks may be supplied to provide *night* conditions from Saturday noon or night to Monday morning.

Oil Burner Controls

In the normal oil burner installation as encountered in residential and small commercial installations, the burner operation is frequently regulated by electric controls and primarily governed by a room thermostat. It is essential that a limiting control be incorporated in the control system to prevent the temperature of the heating medium from exceeding any predetermined safe maximum. The type of limit control selected will depend on the type of the heating system. In a warm air furnace installation, a limit control would be used, reacting to the temperature of the heated air in the bonnet of the furnace; in a hot water system a control reacting to the temperature of the water in the boiler; and in a steam system a control reacting to the pressure of the steam in the boiler.

In addition to the normal control of the burner from the room thermostat and limit control, it is necessary that a combustion safety device be used to prevent operation of the burner under hazardous conditions. The oil fire is automatically ignited by means of gas, electric spark or incandescent element and the combustion safety control acting through a sequence device permits the burner operation only when the fire is properly established as the burner starts up. A further function of the combustion safety control is to react to any major disturbance in the flame during the running operation, shutting down the burner and preventing the discharge of unburned fuel if for any reason the flame is extinguished.

Gas Burner Controls

In the case of the domestic burner, full automatic operation is the normal requirement and the burner is started and stopped at the command of a room thermostat which, in turn, opens and closes a control valve in the gas supply line. Modulating controls and controls providing a high and low fire are also available for gas burners. For purposes of preventing abnormally high temperatures in the bonnet of gas-fired furnaces or in the temperature of the water in gas-fired hot water heating boilers or excessive pressures in gas-fired steam boilers, temperature and pressure limit controls are used. Ignition is normally secured through the use of a gas pilot flame and a safety device is provided, utilizing the heat of the pilot flame in such a manner that if the pilot light is extinguished for any reason, the main gas valve cannot be opened. For satisfactory

and economical operation, all automatically-fired gas burners should be equipped with pressure regulators on the gas supply line.

Stoker Controls

Domestic stokers are normally placed under command of a room thermostat for primary operation subject also to the command of a limit control to prevent their operation when conditions in the boiler or furnace exceed predetermined safe maximums. Utilizing coal as fuel, automatic ignition is not provided and the stokers, once ignited, maintain their fire, merely changing the rate of combustion by changing the draft and the rate at which the coal is fed. Thus, at the command of the room thermostat the stoker motor is started, driving a forced draft fan and fuel feeding mechanism. The rate of combustion is thus increased and this operation continues until the thermostat has been satisfied when the motor is stopped and the fuel in the combustion chamber continues to burn at a slow rate with reduced draft.

At certain seasons of the year, the operation of the stoker under the requirements of the thermostat may be so infrequent that there is a possibility of the fuel in the combustion chamber burning out or the fire going out between operations. To prevent this occurrence, automatic controls may be utilized to operate the stoker independently of thermostat requirements, sufficiently to sustain the fire either through a timing device functioning for short periods at predetermined intervals or through a temperature control device reacting to minimum stack or boiler temperatures. Control may also be utilized to prevent stoker operation and the delivery of coal into the combustion chamber in the event that the fire has gone completely out. This control is governed normally by the stack temperature and shuts down the stoker after a predetermined minimum stack temperature is reached.

RESIDENTIAL CONTROL SYSTEMS

The control installation in a residence may vary from the simple regulation of a coal-fired heating plant to the completely automatic all year air conditioning system. Residential installations with automatic fuel burning appliances, such as oil burners, gas burners or stokers, are normally equipped with single room thermostat, limit and safety controls as outlined previously under Control of Automatic Fuel Appliances.

Coal-Fired Heating Plant

Control in the normal coal-fired domestic heating plant consists of regulating the combustion rate in accordance with requirements. This function is accomplished by a spring or electric-driven damper motor which, under the command of a room thermostat and through chain linkage, operates the draft and check dampers of a boiler or warm air furnace. Such installation should be protected against excessive temperature or pressure by means of a limit control serving to check the fire when conditions at the boiler or furnace reach a predetermined maximum.

All Year Domestic Hot Water Supply

Hot water or steam heating boilers with automatic fuel burning appliances can be used for all year heating of domestic water supply. The

fuel burning appliance in this case is controlled from the temperature of water or pressure of steam in the boiler to maintain uniform boiler conditions and domestic hot water is heated by means of an indirect heater. The heating of the residence is normally governed by means of a thermostat which operates a control valve in the flow line of a gravity hot water or a steam system.

Air Conditioning Systems

Residential air conditioning systems normally include a heating source and a motor-driven fan for circulating air. In addition, such installations may involve spray-head equipment to supply humidity. Such installations distribute suitably heated and humidified air during the heating cycle, and during the summer or cooling cycle may be used effectively as conditioners if equipped with refrigeration means.

Regulation of the humidity during the heating cycle is normally accomplished by opening and closing a solenoid water valve supplying water to the spray-heads, the solenoid valve being under control of a room type humidity control. In the average installation the fan is permitted to run only during such intervals as the thermostat is calling for heat or at the command of a limit control to prevent the overheating of the bonnet of a warm air furnace. The limit control should also prevent the operation of the fan at the command of the thermostat until the circulating air temperature has increased to a predetermined point.

For the cooling equipment provided in such installations, control during the cooling cycle will be an adaptation of the control principles described for central fan systems selected for the type of cooling equipment utilized.

The selection of automatic control equipment for residential air conditioning systems is just as important as for commercial installations. Fewer controls are generally used and systems are usually less complicated except in the case of a very large residence installation when the control system may become as complete as the commercial installation.

CONTROL OF REFRIGERATION EQUIPMENT

The most common means of providing cooling for air conditioning may be divided into four general classifications as follows:

Compressor Type Refrigeration

Refrigeration compressors may furnish refrigerant to direct expansion cooling coils through which air is being passed, or to coils in cooling tanks through which water is passed which is then pumped to air washers or cooling coils through which the air is passed.

In either case the compressor motor may be started and stopped in order to meet the demand for refrigeration or a pressure controller may be used to regulate the low side or suction pressure of the compressor. When the latter method is used, the flow of refrigerant to cooling coils may be regulated by the opening and closing of a solenoid refrigerant valve at the command of a temperature controller or thermostat.

A high pressure cutout as an individual unit or in combination with

either a temperature or pressure controller provides a safety feature against excessive pressures on the high side of the compressor.

Many compressors may be *unloaded* by instruments sensing room or duct conditions, or by refrigerant pressures, thus reducing the frequency of starting and stopping. If two or more compressors are used for a single cooling system, *step controllers* are used to start them in sequence at intervals of a few seconds to avoid the large momentary electric input that simultaneous starting would demand.

When condensers are water cooled, thermostatic control to vary the quantity of water is needed for economical operation. Mechanical air condensers may be started and stopped with temperature demands.

Chilled water may be stored in tanks at temperatures slightly lower than required for air cooling coils. The control of temperature for the water distribution system is as described for Ice Cooling.

Ice Cooling

When ice is used for the cooling or dehumidification of air, it is usually placed in bunkers and water is sprayed over it. This water, after being cooled, may be used in air washers or surface cooling coils and is usually returned to the bunker for additional cooling after being used.

Control of the water temperature leaving the cold water tank may be maintained by a temperature controller, which measures the temperature of the water in the tank and modulates a control valve in a by-pass which permits a portion of the return water to return directly to the tank instead of passing through the sprays.

Vacuum Refrigeration

A vacuum refrigerating system consists of an evaporator, compressor, condenser and auxiliaries. The refrigerant used is water, and water vapor (steam) is the power medium.

Water which has been passed through an air washer or cooling coil is sprayed directly into the evaporator or water cooler where it is cooled by its own evaporation. A condenser is attached directly to the compressor discharge and its function is to recondense the water vapor drawn from the evaporator, plus the steam which supplies the energy for compression.

The temperature of the cold water leaving the flash chamber should be measured by a temperature controller which will in turn operate a two-position or positive-control valve installed in the steam line to the jet so as to permit steam to flow only when cooling is required. If city water is used in the condenser, the amount of water should be modulated according to the demand as measured at the condenser outlet by means of a temperature controller and control valve.

Cooling by Well Water

When well water is available in sufficient quantities at low temperatures during the cooling season, it may be pumped directly to air washers or cooling coils. Control is usually effected through control valves on the water supply to the cooling unit actuated by temperature or humidity controllers, or both, located either at the outlet of the conditioner or in the conditioned space.

Chapter 35

INSTRUMENTS AND TEST METHODS

Temperature Measurement, Pressure Measurement, Measurement of Air Movement, Air Change Measurements, Measurement of Relative Humidity, Dust Determination, Heat Transfer Through Building Materials, Measurement of Heat Exchange for Comfort Conditions, Combustion Analysis, Smoke Density Measurements, Carbon Monoxide Measurements

IN previous chapters, data from many tests and from much research on various divisions of heating, ventilating and air conditioning have been given. References have also been cited to a number of test codes adopted by the Society for the testing and rating of various types of equipment. This chapter presents a description of many test instruments, and discusses their use.

TEMPERATURE MEASUREMENT

Changes in the intensity of heat may be determined by several methods such as measuring the change in volume of a liquid, the change in internal pressure of a confined gas, the current set-up between dissimilar metals joined in a circuit, or the change in resistance of an electrical circuit.

Thermometers

The most common method used is the change in volume of a liquid such as mercury or alcohol enclosed in glass. Mercurial thermometers may be used for measuring temperatures from -40°F to approximately 1000°F . The lower limit is set by the freezing point of mercury. Since the boiling point of mercury is only about 675°F , the space above the mercury in thermometers designed for higher temperatures must be filled with an inert gas under pressure. Alcohol thermometers may be used for temperatures from -94°F to $+248^{\circ}\text{F}$.

The more accurate thermometers are individually calibrated and have divisions etched on the stem. The two most common reference points are the freezing and boiling points of water. On the Fahrenheit scale, which is most commonly used in engineering work, there are 180 divisions between these points. On the Centigrade scale which is used by chemists and physicists, there are 100 divisions in this range. The temperature in degrees Fahrenheit equals $\frac{9}{5}$ of the temperature in degrees Centigrade, plus 32.

For permanent installations, glass thermometers are often protected by metal jackets and equipped with metal scales. Due to the heat

capacity and heat conductance of the jacket, it is more difficult to obtain the true temperature at a point with these than with the exposed etched stem type. The latter is usually preferred for test purposes. Where used to measure temperatures in a duct, it may be inserted through a cork or rubber plug. Care must be taken to locate the bulb at the point where the temperature is desired and in many cases several must be used to get a correct average.

Most mercury thermometers are calibrated for complete stem immersion. When incompletely immersed, a stem correction should be made for the most accurate determination. At ordinary atmospheric temperatures the correction is negligibly small, but it usually is important when measuring high temperatures such as those of steam and flue gas. The emergent stem correction may be calculated by the equation:

$$K = 0.00009 D (t_1 - t_2) \quad (1)$$

where

K = correction to be added, degrees Fahrenheit

D = number of degrees on the thermometer scale which are not immersed.

t_1 = temperature indicated on the thermometer, degrees Fahrenheit.

t_2 = temperature of the non-immersed mercury column, degrees Fahrenheit.

0.00009 = difference in the coefficient of expansion of the mercury and glass.

In some cases, thermometers are calibrated for a certain depth of immersion indicated by an etched mark on the stem. Should such a thermometer be used for full immersion, a negative stem correction would be in order. In selecting a set of thermometers for a test, it is well to compare the group by immersion in a common bath and note variations. The more accurate ones can thus be selected for the more important positions. The interchanging of thermometers at inlet and outlet tends to cancel variations and therefore may result in greater accuracy. In extreme cases of small temperature differences involving large quantities of heat, it may be advisable to use thermometers graduated in tenths of degrees and mount magnifying glasses on them for accurate reading.

Since the bulb has considerable area, radiant energy may affect temperature readings¹. In measuring room temperatures, care must be taken to locate thermometers away from hot surfaces such as radiators or cold surfaces such as walls or windows. Where this is impractical, shields should be used to screen the bulb from the radiant energy.

Thermocouple

When two dissimilar metals are joined at two points and a temperature difference exists between these junctions, an electromotive force will be developed. Its magnitude depends upon the metals used and the temperature difference of the two junctions. Often the cold junction is kept at 32 F by immersion in an ice bath. In other instances, a higher temperature such as that of the atmosphere is used for this junction. By proper selection of metals, any temperature up to 2900 F may be measured. Readings are obtained by means of a potentiometer or sensitive

¹Errors in the Measurement of the Temperature of Flue Gases, by P. Nicholls and W. E. Rice (A.S.H.V.E. TRANSACTIONS, Vol. 35, 1929, p. 473).

galvanometer which may be calibrated directly in degrees. A potentiometer balances the electromotive force against a known electromotive force with no current flowing, hence this method is independent of length and variations in resistance of leads. Calibration of thermocouples for high temperatures may be made against known melting points of metals. Radiation effects may be minimized by using the smallest size of wires consistent with mechanical strength. The use of small wires also makes the thermocouple sensitive to minute fluctuations in temperature.

Other advantages of thermocouples are: they are readable at remote points, they may be made recording, and an average temperature may be readily obtained by connecting several couples in series.

Resistance thermometers depend for their operation upon the change of resistance of wire with change in temperature. Their use largely parallels that of thermocouples. Various metals may be used and the range is about the same as for thermocouples.

For measuring high temperatures, such as in furnaces, *pyrometers* are often used. Radiation pyrometers concentrate the radiant energy on a thermopile, and the reading is obtained on a galvanometer or potentiometer. Optical pyrometers match a narrow spectral band, usually red, emitted by the object with that from a standard electric lamp supplied with electric current.

PRESSURE MEASUREMENT

Barometer

The most accurate barometer for determining the atmospheric pressure is the mercurial type, consisting of a tube over 30 in. long closed at the top and standing in a mercury well. The barometric pressure is expressed as the height of the mercury column above the level of the mercury in the well. Such barometers are equipped with an adjustment to compensate for change in level of mercury in the well. The reading at the tube meniscus is obtained on a vernier scale. When extreme accuracy is required, as in determining the thermodynamic properties of vapors at very low absolute pressures, corrections for the variation of density of the mercury column with temperature should be made. Standard density of mercury is taken at 32 F and the conversion factor from inches of mercury to pounds per square inch is 0.491.

Equation 2 may be used to make corrections for temperature variations from 32 F for mercury columns:

$$h = h_1 [1 - 0.000101 (t_1 - 32)] \quad (2)$$

where

h = corrected column at 32 F, inches mercury.

h_1 = measured height of the column, inches mercury.

t_1 = observed temperature of the column, degrees Fahrenheit.

Standard atmospheric pressure at sea level is 29.921 in. mercury. Since normal atmospheric pressure decreases about 0.01 in. mercury for each 10 ft increase in elevation, it is important to make a correction if the elevation of the barometer is not that of the test apparatus. In many cases the barometric reading may be obtained from a nearby weather

bureau station. Inquiry should be made as to whether the value is as observed or corrected to sea level.

Atmospheric pressure may also be measured by an aneroid barometer which is easily portable. In this type, variations in atmospheric pressure bend the thin surface of a box or tube which contains a reduced pressure. The aneroid type is not as accurate as the mercurial and needs frequent calibration against one of the latter type. Most of the pressure gages used in engineering work indicate the difference between the pressure being measured and the atmospheric pressure. Pressures as measured are called gage pressures. Absolute pressure may be obtained by adding barometric pressure and gage pressure algebraically.

Pressure Gages

The Bourdon type gage is a widely used device for measuring pressures. The Bourdon tube is elliptical in cross-section and circular in form, and is connected by suitable linkage to a hand which moves over a dial. An increase in pressure tends to straighten the tube and a decrease has the opposite effect. When used with high temperature steam, the tube must be protected by a water seal. When used with ammonia it must be made of steel or other material not attacked by this substance. When used for sub-atmospheric pressure, the gage is known as a vacuum gage, and is usually graduated in inches of mercury. For pressures above atmospheric, it is termed a pressure gage and is graduated in pounds per square inch. Some are made to read in both directions and are termed compound gages. Calibration is usually made with a dead weight tester, consisting of a platform and weights resting on a piston floating on oil. From the area of the piston and the total weight resting on the oil, the pressure at all points in the fluid is determined. Adjustments are provided in the gage linkage to make necessary corrections. A correction chart may also be made and used for accurate work.

For comparatively low gage pressures above and below atmospheric, the vertical U tube is a simple and accurate gage and is often used for test work with various fluids such as mercury, water, kerosene, or alcohol. Readings may be in inches of any of these fluids.

For measuring pressures within a few inches of water of atmospheric pressure, U gages are often made sloping for greater magnification of scale. In commercial gages of this type, commonly termed *draft gages*, only one tube of small bore is used and the other leg is replaced by a reservoir. Although the scale is calibrated to read in inches of water, a fluid having the density and characteristics of kerosene is often used. It is important, of course, to use a fluid having the same gravity as that for which the gage was originally calibrated, or to use a correction chart with some other fluid. Such gages may be checked one against another to detect errors in gravity of fluid. For more accurate calibration the gage may be checked against a calibrating device working on the U gage principle which uses hook gages and a micrometer screw. It is not considered desirable to use a slope of less than 1 to 10 in the design of these gages. The accuracy of a draft gage is very dependent on the slope which is usually fixed by a built-in spirit level. If one side of a U gage is open to the atmosphere, the gage indicates pressure above or below atmos-

pheric pressure. If both sides are connected, it indicates the difference in pressure existing between the two points of connection.

For measuring extremely low pressures accurately, very sensitive *micromanometers* of several types are available, such as the Chatelier, the Illinois or Wahlen and the Emswiler^{2,3}. Calibration of these by a hook gage is impossible, and recourse must be made to fundamental calculations involving gravity of fluids and the principles involved. When proved accurate, a micromanometer is very useful for calibrating draft or slant gages.

MEASUREMENT OF AIR MOVEMENT

The problem of measuring air movement may be divided into three main parts: when confined in ducts, when circulating in free spaces, and when entering or leaving such space through openings such as grilles. Other gases might be measured by the same methods, but emphasis here will be on air measurements⁴.

For determining the velocity, and therefore the volume of air flowing in a duct, such as in the test of a fan or a complete ventilating system, the Pitot tube as described in the A.S.H.V.E. Code⁵ is probably most often used. The tube is a double tube $\frac{5}{16}$ in. outside diameter with a rounded end up-stream. The inner tube is $\frac{1}{8}$ in. inside diameter at the up-stream end, and the pressure in it is the sum of the velocity pressure and static pressure at its location in the duct. The outer tube, otherwise sealed, has 8 holes 0.04 in. in diameter and equally spaced around the circumference, and located eight diameters down-stream. A connection to this tube gives the static pressure. If both tubes are connected to opposite ends of a *U* gage, the gage indicates velocity pressure. At low velocities the resulting pressure head is so low that it becomes difficult to get accurate gage readings. The velocities used in many ducts are below the lower limit of determination with gages available. The relation between velocity and velocity pressure may be used to determine the range of gage required.

$$V = 1096.2 \sqrt{\frac{h_v}{d}} \quad (3)$$

where

V = velocity, feet per minute.

h_v = velocity pressure, inches of water.

d = density of air, pounds per cubic foot.

Air flow in a round duct is seldom uniform. In general, the velocity is lowest near the edges, and maximum at or near the center. In order to obtain higher velocities and more uniform flow across the measuring section, it is sometimes possible to reduce the duct to a smaller cross

²Illinois Micromanometer (*University of Illinois, Engineering Experiment Station Bulletin* No. 120, p. 91).

³The Weathertightness of Rolled Steel Windows, by J. E. Emswiler and W. C. Randall (A.S.H.V.E. TRANSACTIONS, Vol. 34, 1928, p. 527).

⁴For technical data refer to Fluid Meter Reports, Parts 1—1937, 2—1931, and 3—1933 (*American Society of Mechanical Engineers*).

⁵Standard Test Code for Centrifugal and Axial Fans, Edition of 1938. See also Standard Code for the Testing of Centrifugal and Disc Fans (A.S.H.V.E. TRANSACTIONS, Vol. 29, 1923, p. 407; Vol. 37, 1931, p. 363).

section at the Pitot station by use of a long transition piece. In any case, a large number of readings in two traverses should be taken, with 20 being quite desirable. These should be taken at the centers of equal areas for correct determination of volumes. For round pipe, these would be located from the center by multiplying the radius by the following factors: 0.316, 0.548, 0.707, 0.837 and 0.961. A fundamentally correct method of measurement is obtained with a Pitot tube and therefore it can be used without calibration. For small pipes it is sometimes necessary to construct a Pitot tube smaller than the standard size. Such a small Pitot tube should be geometrically similar to the standard tube. Pulsating or disturbed flow will give erroneous results and every effort should be made to remove disturbances in the Pitot tube section.

Many forms of Pitot tubes other than the one described have been used and calibrated⁶. A double-ended tube, one end pointing down-stream, and one up-stream, is sometimes used for low velocities, but it should be carefully calibrated for accurate results. A special form of this tube design consists of two straight $\frac{1}{8}$ in. tubes soldered together, closed at the end, and with a 0.04 in. hole in each tube opposite the line of contact. This tube is useful in exploring velocities on exhaust inlets, such as on hoods placed around grinding wheels.

The rounded approach orifice or nozzle of the general type described in the A.S.H.V.E. Unit Heater⁷ and Unit Ventilator⁸ Codes is an accurate air measuring device. When it is well made, the coefficient closely approaches unity. The velocity at the mouth is increased over that in the duct, and the resulting increased velocity pressures may be measured accurately. The discharge from such a nozzle is uniform⁹ and provides a good location for calibration of air velocity instruments¹⁰.

The Venturi meter is like the nozzle except for the addition of a down-stream transition section that reduces the friction drop through the measuring apparatus. Since a good one is expensive, the Venturi meter is seldom used with gases, although it is often used to measure liquids.

The thin-plate square-edged orifice has a decided advantage over the rounded approach orifice in cost. Its coefficient is approximately 0.60. The exact value depends on the location of the connections, the pressure drop, the diameter ratio of orifice to pipe, and the sharpness of the edge¹¹.

Another method of air measurement uses the thermal electric principle where by means of a measured amount of current, heat is put into the air stream. The temperature rise is measured, and with the specific heat of the air mixture known, the weight of air flowing may be calculated. Heat should be applied uniformly to the mass of air passing, and the small temperature difference must be determined accurately.

⁶Technical Notes No. 546, (*National Advisory Committee for Aeronautics*, November, 1935).

⁷Standard Code for Testing and Rating Steam Unit Heaters (A.S.H.V.E. TRANSACTIONS, Vol. 36, 1930, p. 165).

⁸Standard Code for Testing and Rating Steam Unit Ventilators (A.S.H.V.E. TRANSACTIONS, Vol. 38, 1932, p. 25).

⁹Discharge Coefficients of Square Edged Orifices for Measuring the Flow of Air, by H. S. Bean, E. Buckingham and P. S. Murphy (*Bureau of Standards Journal Research*, Vol. 2, 1929, p. 561).

¹⁰A.S.H.V.E. RESEARCH REPORT No. 1140—The Use of Air Velocity Meters, by G. L. Tuve, D. K. Wright, Jr., and L. J. Seigel (A.S.H.V.E. TRANSACTIONS, Vol. 45, 1939, p. 645).

¹¹Flow Measurement by Nozzles and Orifice Plates (A.S.M.E. Power Test Codes, Chapter 4 of Part 5, 1940).

Air Currents in Free Spaces

One of the instruments useful in determining the velocity of air currents in free spaces is the Kata-thermometer. It is essentially an alcohol thermometer with a large bulb. The stem has two marks, one corresponding to 95 F, and the other 100 F. The instrument is heated above 100 F, and the time in seconds required for it to cool from 100 to 93 when placed in the air current gives a measure of the non-directional velocity. The usual way of heating the bulb is in a water bath, and it is important to wipe the Kata-thermometer dry before taking the reading. A thermostatically controlled water bath is very convenient to use along with two instruments so one may be heating while the other is in use. For high atmospheric temperatures the high temperature Kata with a range of 130 to 135 F may be used. Usually several readings are taken in a given location and the average used. Each Kata has its own factor etched on the stem, and this factor must be used with the cooling formula or chart for obtaining the velocity. The Kata-thermometer is useful in exploring ventilated spaces to determine whether the proper air movement and distribution is being maintained. The Kata-thermometer also finds use in determining the cooling power of the atmosphere, since it loses heat by radiation and convection when dry, and by radiation, convection, and evaporation when the bulb is equipped with a wetted cloth covering¹².

Another instrument for measuring low velocity air currents is the heated thermometer anemometer¹³. This consists of an ordinary mercurial glass thermometer with a resistance winding on the bulb. Current is supplied from an external source in a measured amount. The temperature rise shown on this heated thermometer over that shown by an ordinary thermometer at the same location, and the current supplied, make it possible to calculate the non-directional velocity of the air stream. Since a smaller bulb is used than that on the Kata-thermometer, it is less affected by radiant heat sources.

Another instrument is the hot wire anemometer which is available in several patterns. In general, a measured current is supplied to raise the temperature of a fine bare wire above the temperature of the surrounding air. With the use of a very fine wire, minute fluctuations in velocity may be measured, and the area exposed to radiant exchange with heated or cooled surfaces is at a minimum. This instrument is easily made remote reading or recording. A group of them may be connected together to give the average velocity in a space, or the velocity at individual points within a test space, by suitable switching arrangements^{14,15}.

Deflecting Vane Anemometer

The deflecting vane anemometer consists of a pivoted vane enclosed in a case, against which air exerts a pressure as it passes through the instrument from an up-stream to a down-stream opening. The movement of the vane is resisted by a hair spring and a damping magnet.

¹²Temperature, Humidity and Air Motion Effects in Ventilation, by O. W. Armspach and Margaret Ingels (A.S.H.V.E. TRANSACTIONS, Vol. 28, 1922, p. 103)

¹³The Heated Thermometer Anemometer, by C. P. Yaglou (*Journal Industrial Hygiene and Toxicology*, Vol. 20, October 1938, No. 8)

¹⁴Development of Testing Apparatus for Thermostats, by D. D. Wile (A.S.H.V.E. TRANSACTIONS, Vol. 42, 1936, p. 349)

¹⁵Linear Hot Wire Anemometer, Its Application to Technical Physics, by L. V. King (*Journal Franklin Institute*, 1916)

The instrument gives instantaneous readings of directional velocities on an indicating scale. When used in fluctuating velocities, it is necessary to average visually the swings of the needle to obtain average velocities. This instrument is very useful in locating and measuring peak velocities that may be objectionable in air conditioned spaces. Various attachments are available, such as a double tube arrangement for obtaining velocities in ducts, and a device to measure static pressures. Another attachment will be mentioned later under the measuring of velocities at inlets and outlets. Each instrument and the attachments for it must receive individual calibration.

The deflecting vane anemometer is useful for studying the mixing of air in a room with the conditioned air from a supply outlet. Effects of air velocity, size and shape of outlet and angle of stream may be evaluated, using the principle of conservation of momentum¹⁶.

Propeller or Revolving Vane Anemometer

The propeller or revolving vane anemometer consists of a light revolving wheel connected through a gear train to a set of recording dials that read the linear feet of air passing in a measured length of time. It is made in various sizes, 3 in., 4 in., and 6 in. being most common. Each instrument requires individual calibration. At low velocities the friction drag of the mechanism is considerable. In order to compensate for this, a gear train that overspeeds is commonly used. For this reason the correction is often additive at the lower range and subtractive at the upper range with the least correction in the middle range of velocities. Most of these are not sensitive enough for use below 200 fpm; therefore, they are not commercially available for the low velocity range met with in air conditioned spaces.

Measurement of Velocities at Inlets and Outlets of Ducts

In the field it is often advisable to make volume measurements at the face of the supply openings. Often it is hard to get into the duct system, or it is difficult to find sections where the flow would be sufficiently uniform. The many types of approaches and grilles used make a high degree of accuracy almost impossible. For accuracy the instrument and its application should be checked on a similar approach and grille in the laboratory before use in the field. Where extreme accuracy is not required, as in balancing a system, various instruments may be used.

Tests have shown that the propeller type anemometer can be used successfully on most of the common types of supply grilles^{17,18}. The core area is divided into equal squares, and the anemometer is held against the face of the grille for the same length of time in each. To get the air volume in cubic feet per minute, the average corrected velocity in feet per minute thus obtained is multiplied by the average of the gross and net free area of the grille (core) in square feet.

¹⁶A.S.H.V.E. RESEARCH PAPER—Entrainment and Jet-Pump Action of Air Streams, by G. L. Tuve, G. B. Priester and D. K. Wright, Jr. (A.S.H.V.E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, November, 1941, p. 708).

¹⁷A.S.H.V.E. RESEARCH REPORTS Nos. 857, 911 and 966—Measurement of the Flow of Air Through Registers and Grilles, by L. E. Davies (A.S.H.V.E. TRANSACTIONS, Vol. 36, 1930, p. 201, Vol. 37, 1931, p. 619, and Vol. 39, 1933, p. 373).

¹⁸A.S.H.V.E. RESEARCH REPORT No. 1162—Air Flow Measurements at Intake and Discharge Openings and Grilles, by G. L. Tuve and D. K. Wright, Jr. (A.S.H.V.E. TRANSACTIONS, Vol. 46, 1940, p. 313).

On exhaust grilles, the anemometer traverse is made as described previously. The air volume may be determined by multiplying the corrected velocity in feet per minute by the gross core area of the grille in square feet and by a coefficient for average conditions of 0.85. This coefficient allows for the interference of the grille bars and the effect on the anemometer of the air entering an exhaust grille through 180 deg¹⁹.

When a propeller type anemometer is held in a stream of varying velocities, it tends to indicate higher than the true average, that is, the speed of the propeller is nearer to the top velocity in its area than it is to the minimum velocity. This is the main reason for the large difference in ratings of unit ventilators by the anemometer method and by air volume measurements in a duct approach to the inlet²⁰.

Any of the other anemometers described can be used within their range at the face of supply grilles when properly applied. In principle it is a case of finding the velocity at many points and using the average thus found with the correct discharge area at that cross-section. The deflecting vane anemometer equipped with a jet on the end of a rubber tube has been found especially convenient and accurate on supply grilles²¹. On modern air conditioning grilles the core area is used without a correction coefficient when the jet is held one inch away from the face of the grille. At this distance the constriction due to the thin bars has disappeared since the small air jets have reunited, and the air stream has not yet spread beyond the core dimensions. With deflecting grilles the exploring jet should be turned to the angle giving a maximum reading. This method of using this instrument is only applicable to supply grilles and cannot be used on exhaust grilles because of static pressure differences at the location of the jet and the instrument case.

While hardly a quantitative instrument, smoke is very useful in studying air streams and currents. The application of a more accurate instrument is often made more exact by a preliminary exploration with smoke. A mixture of potassium chlorate and powdered sugar in equal portions gives a very satisfactory non-irritating smoke. It is fired by a match, and since considerable heat is evolved, it should be placed in a pan away from inflammable objects.

AIR CHANGE MEASUREMENTS

Atmospheric air contains a certain amount of carbon dioxide. Its concentration is increased within enclosures by the carbon dioxide given off by occupants. The air changes through all means: open windows, infiltration, and mechanical ventilation, may be measured by the carbon dioxide concentration²². The Petterson-Palmquist apparatus has been accepted as the standard device for the determination of carbon dioxide in air. The principle used is absorption by caustic potash solution of the carbon dioxide in a known volume of air, and a remeasurement of the volume in a finely graduated capillary tube. Since the concentrations

¹⁹A.S.H.V.E. RESEARCH REPORT No. 1092—The Flow of Air Through Exhaust Grilles, by A. M. Greene, Jr., and M. H. Dean (A.S.H.V.E. TRANSACTIONS, Vol. 44, 1938, p. 387).

²⁰A.S.H.V.E. RESEARCH REPORT No. 936—Investigation of Air Outlets in Class Room Ventilation, by G. L. Larson, D. W. Nelson and R. W. Kubasta (A.S.H.V.E. TRANSACTIONS, Vol. 38, 1932, p. 463).

²¹A.S.H.V.E. RESEARCH REPORT No. 1076—Air Distribution From Side Wall Outlets, by D. W. Nelson and D. J. Stewart (A.S.H.V.E. TRANSACTIONS, Vol. 44, 1938, p. 77).

²²A.S.H.V.E. RESEARCH REPORT No. 959—Indices of Air Change and Air Distribution, by F. C. Houghten and J. L. Blackshaw (A.S.H.V.E. TRANSACTIONS, Vol. 39, 1933, p. 261).

are in the order of 3 to 10 parts in 10,000, extreme care must be used to obtain accurate determinations. Since occupants also give off moisture, the increase in humidity may also be used as an index of ventilation within a space. Humidity determinations are much simpler to make, but the accuracy may be affected slightly by absorption of moisture by hygroscopic materials such as fabrics and wood within the space. Measured amounts of either carbon dioxide or water vapor may be added for test purposes. Neither method is used at the present time, and more direct methods of measuring air supply and air distribution are in favor.

MEASUREMENT OF RELATIVE HUMIDITY

Wet- and dry-bulb mercurial thermometers are usually used to determine relative humidity. The sling psychrometer is a common mounting of the thermometers to permit swinging. The wet-bulb wick and water for wetting it must be clean, and the temperature of the water should preferably be slightly above the wet-bulb temperature. An air stream velocity of 900 fpm is recommended, although velocities from 300 fpm to 1000 fpm have been found satisfactory for passage over the wet-bulb wick. The velocity may be obtained by whirling the thermometer or by aspirating air over the wet-bulb. In ducts, the air flow itself gives the proper evaporating conditions. Several observations should be made until the minimum temperature is reached. Relative humidity may be obtained from tables or psychrometric charts²³. Although it is common practice to use the charts which are based on a barometric pressure of 29.92 in. mercury, a correction for barometric pressure is necessary for extreme accuracy. This correction is made by multiplying the relative humidity as determined from the chart by the ratio of the observed barometric pressure and the standard barometric pressure.

For temperatures below 32 F, the water on the wick is allowed to freeze, during which time the temperature will drop below the true wet-bulb. A thin film of ice is more desirable than a thick one, and it is satisfactory to remove the wick and freeze a thin film directly on the bulb. Care must be taken to read the temperatures accurately due to the slight wet-bulb depressions. Tables for ice conditions must be used²⁴.

The dew-point apparatus for humidity measurements consists of a polished plated container cooled by the evaporation of a volatile liquid within. The temperature at which the first slight water vapor forms is the dew-point. If the temperature is below 32 F, the deposit will appear as frost. Another method of determining humidity is by chemical means in which the water vapor is removed by a drying agent and weighed on a chemical balance. A thermal conductivity method is available for temperatures above 212 F or for extremely low humidities²⁵.

DUST DETERMINATION

The measurement of dust is complicated by the many kinds involved. Some of the collecting methods are impingement on viscous surfaces,

²³Psychrometric Tables for Vapor Pressure, Relative Humidity and Temperatures of the Dew-Point, (U. S. Department of Agriculture, Weather Bureau, Washington, D. C.).

²⁴A Review of Existing Psychrometric Data in Relation to Practical Engineering Problems, by W. H. Carrier and C. O. Mackey (*A.S.M.E. Transactions*, January, 1937, p. 33; Discussion, *A.S.M.E. Transactions*, August, 1937, p. 528).

²⁵Gas Analysis by Measurement of Thermal Conductivity, by H. A. Daynes (*Cambridge Press*, 1933).

impingement at high velocity under water, collection on porous crucibles through which air passes, and electric precipitation. Determination may be by direct weighing of samples or by microscopic counting. The most commonly used methods are the modified Hill dust counter using microscopic count, the Smith-Greenburg impinger which collects samples in water and which are counted under a microscope in a Sedgwick cell²⁶, and the Lewis sampling tube with the analytical determination of the increase in weight of a porous crucible. All reports should state the method of sampling and counting. The A.S.H.V.E. Code for Testing and Rating Air Cleaning Devices Used in General Ventilation Work specifies the porous crucible method²⁷.

HEAT TRANSFER THROUGH BUILDING MATERIALS

The A.S.H.V.E. Standard Test Code for Heat Transmission Through Walls²⁸ describes the construction and use of the guarded hot box for determining overall heat transmission coefficients of built-up sections. The standard temperature range through the test section is specified as 80 F and the mean temperature of the wall as 40 F.

In June, 1942, the A.S.H.V.E. adopted a standard test procedure for determining the conductivity of materials by the use of a guarded hot plate²⁹. The Nicholls heat meter is very useful for determining the heat flow through walls of buildings³⁰.

MEASUREMENT OF HEAT EXCHANGE FOR COMFORT CONDITIONS

Several instruments have been devised to measure the effect of various factors as they relate to the comfort of the body³¹. The principal ones are the Kata-thermometer, Dufton's eupatheoscope, Vernon's globe thermometer, Winslow and Greenburg's thermo-integrator, and Yaglou's heated globe^{32,33}. These instruments are attempts to stimulate and measure the heat exchanges between the human body and its environment. In order to stimulate conditions of hard physical labor, the entire surface of the device is covered with a wet cloth. At present special attention is being given the thermo-integrator as a means of measuring radiant effects of environmental conditions.

COMBUSTION ANALYSIS

The analysis of flue gases to determine completeness and efficiency of combustion is usually made chemically with the Orsat apparatus. This

²⁶Public Health Bulletin, No. 144, 1925, (*U. S. Public Health Service*).

²⁷Testing and Rating of Air Cleaning Devices Used for General Ventilation Work, by S. R. Lewis (A S.H.V.E. TRANSACTIONS, Vol. 39, 1933, p. 277)

²⁸A.S.H.V.E. Standard Test Code for Heat Transmission Through Walls (A S.H.V.E. TRANSACTIONS, Vol. 34, 1928, p. 253).

²⁹Standard Method of Test for Thermal Conductivity of Materials by Means of the Guarded Hot Plate (Tentative). Reprints of this code are available at \$ 10 a copy.

³⁰A.S.H.V.E. RESEARCH REPORT No. 685—Measuring Heat Transmission in Building Structures and a Heat Transmission Meter, by P. Nicholls (A.S.H.V.E. TRANSACTIONS, Vol. 30, 1924, p. 65).

³¹Measurement of the Physical Properties of the Thermal Environment, by D. W. Nelson, F. R. Bichowsky, L. M. K. Boelter, R. S. Dill, A. P. Gage, John A. Goff, A. E. Hershey, F. C. McIntosh, F. W. Reichelderfer, G. L. Tuve and C. P. Yaglou (A S.H.V.E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, June, 1942, p. 382).

³²Instruments and Methods for Recording Thermal Factors Affecting Human Comfort, by C. P. Yaglou, A. P. Kratz and C.-E. A. Winslow (Year Book, *American Journal Public Health*, 36-37).

³³The Thermo-Integrator—A New Instrument for the Observation of Thermal Interchanges, by C.-E. A. Winslow and Leonard Greenburg (A.S.H.V.E. TRANSACTIONS, Vol. 41, 1933, p. 149).

consists of a measuring burette, a leveling bottle, and three pipettes. Carbon dioxide is absorbed in the first pipette by potassium hydroxide, oxygen in the second by potassium pyrogallate, and carbon monoxide in the third by cuprous chloride. A known volume of gas is drawn in, and after each of the three absorptions the reduced volume is again measured in the burette. Pressure and temperature of the gas sample are kept constant while measuring. Several passes are made through each pipette which contains tubes or glass beads to increase the wetted surface. It is essential that each reaction be completed before the next reaction is started. Since the life of the reagents is limited, it is well to keep a record of the number of samples tested. Care is needed in operation to prevent the pulling of reagents out of the pipettes into the capillary tubing and burette. Many recording gas analyzers are available and are usually found in the larger plants.

SMOKE DENSITY MEASUREMENTS

A common method of determining the relative density of smoke issuing from chimneys is by visual comparison with the Ringelmann Smoke Charts. A sheet of four ruled charts with varying weights of black lines is used. The sheet is 12 by 26 in. overall on which are four charts, each consisting of 294 squares, 14 wide and 21 high. The width of line and spacings are given in Table 1.

TABLE 1. RINGELMANN SMOKE CHART SPACINGS

NUMBER OF CARD	THICKNESS OF LINES, MM	DISTANCE IN CLEAR BETWEEN LINES, MM
1	1.0	9.0
2	2.3	7.7
3	3.7	6.3
4	5.5	4.5

The charts are placed 50 ft from the observer and in line with the stack to be observed. At this distance the lines disappear and the charts appear as varying shades of gray. At times a white chart is added as No. 0 to the left of the four charts 1 to 4, and a black chart to the right as No. 5.

Apparatus using the photo-electric cell has been devised for recording smoke densities in large plants.

CARBON MONOXIDE MEASUREMENT

In garages and vehicular tunnels carbon monoxide is a constant potential danger. In small amounts it causes headaches and inefficiency, and in larger concentrations it causes collapse and death in rather short periods of exposure. A method of analyzing for carbon monoxide concentrations completes the oxidation of the carbon monoxide in a known volume of sample, in the presence of a catalyst. The heat resulting is measured by a thermocouple calibrated in parts per 10,000 of carbon monoxide³⁴.

³⁴A Carbon Monoxide Recorder, by S. H. Katz, D. A. Reynolds, H. W. Frevert and J. J. Bloomfield (U. S. Bureau of Mines, Technical Paper No. 353, 1928).

Chapter 36

MOTORS AND MOTOR CONTROLS

Direct Current Motors, Alterating Current Motors for Single Phase and Polyphase, Special Applications, Classification of Motors, Manual Control, Automatic Control, Pilot Controls, Direct Current Motor Control, Squirrel-Cage Motor Control, Multispeed Motor Control, Wound Rotor Motor Control, Single Phase Motor Control

THE electric motor, available in many different types suitable for various services, is now the most widely used form of prime mover. The equipment for starting, controlling and protecting these motors varies with the type and with the functions it is desired to attain. Motors used for heating, ventilating and air conditioning applications may be divided into two general classifications: (1) for use with direct current, and (2) for use with alternating current.

All driven machinery has certain torque characteristics which may vary with the speed, such as fans, which have sharply increasing torques with increasing speed. Others, such as reciprocating compressors, have a constant torque characteristic with changing speed, while still others such as stokers, may have rising torque with decreasing speed. Motors with suitable torque characteristics should be applied to the driven load.

All electric motors, as with nearly all machines, are rated on the basis of the total temperature which the motor attains under operating conditions as well as other characteristics. The motor temperature is a result of both the ambient temperature and temperature rise of the motor. The motor temperature rise is in turn determined by motor construction and motor losses. In selecting motors careful attention should be given to the ambient temperature, and rated motor rise in order that the resulting motor temperature does not exceed allowable total temperature, otherwise greatly shortened motor life will result. Consult motor manufacturers for allowable temperatures.

DIRECT CURRENT MOTORS

The three types of direct current motors available are: (1) shunt wound, (2) compound wound, and (3) series wound.

Shunt Wound motors, being suitable for application to fans, centrifugal pumps, or similar equipment, where the amount of starting torque required is relatively small, are used for the majority of applications in the field of heating, ventilating and air conditioning. They may be used on reciprocating pumps and compressors, if started under unloaded conditions.

Compound Wound motors are required for application to reciprocating compressors, stokers, reciprocating pumps when started under loaded conditions, and also when applied to similar equipment where high starting torque is required. Whenever frequent starting makes high starting and accelerating torque desirable, or where sudden changes of load are encountered, compound wound motors are used.

Series Wound motors find only limited application in a few special cases and are available in only a limited range of sizes.

Speed Characteristics

Direct current motors are available with speed characteristics of four types:

1. Constant speed.
2. Adjustable speed.
3. Adjustable varying speed.
4. Varying speed.

Constant Speed motors may be shunt wound or compound wound. Shunt wound motors have a nearly flat speed-load characteristic, with a speed regulation, when hot, from full load to no load of 15 per cent for up to $\frac{3}{4}$ hp, 12 per cent for one to 5 hp and 10 per cent for $7\frac{1}{2}$ hp and larger, based on full load speed. Compound wound motors have a speed regulation over the range from full load to no load of not more than 25 per cent, based on full load speed.

Adjustable Speed motors are usually shunt wound since it is impractical to maintain the proper relation between the shunt and series fields of compound wound motors when wide variations of the field strength are required to obtain the speed adjustment.

Adjustment of the speed of shunt wound motors is obtained by field control on motors rated at $\frac{3}{4}$ hp and larger, with the minimum or base speed at full field strength and higher speeds at reduced field strength (obtained by adding resistance in the field circuit). The speed regulation from no load to full load will not exceed 22 per cent for 2 to 5 hp; nor 15 per cent for $7\frac{1}{2}$ hp and larger. Below 2 hp, the regulation may exceed 22 per cent. If closer speed regulation is required, specially wound motors must be obtained.

Motors with a speed range by field control of 3 to 1 or more are considered as adjustable speed, with less than 3 to 1 as constant speed. These motors can be rated on the basis of: (1) tapered continuous horsepower output with constant minimum rated output up to a speed ratio of $1\frac{1}{2}$ to 1 and increasing horsepower up to 3:1 and constant maximum horsepower (next horsepower rating above minimum rated horsepower) above 3:1; with variable motor temperature rise; (2) constant minimum horsepower from 1:1 to 4:1 with variable temperature rise; and (3) constant maximum horsepower from 1:1 to 4:1 with constant temperature rise for one hour operation and then the motor allowed to cool before further operation. High efficiency is maintained over the entire speed range.

Adjustable Varying Speed motors may be either shunt or compound wound and speed adjustment is obtained by adding resistance in series

with the armature. The speed thus obtained is always below the rated full field speed. Any standard shunt or compound wound constant speed motor may be used in conjunction with the proper armature resistor. The usual range of speed reduction is 50 per cent. The speed obtained for any setting of the resistor depends on the load of the motor and will vary with this load.

The speed regulation at high speed is comparable to a constant speed motor, but becomes poorer as the speed is decreased. When operating at reduced speed, an increased torque requirement which the motor could easily handle at rated speed is easily sufficient to stall the motor; for example, a motor operating at two-thirds speed would be stalled by a torque about 50 per cent in excess of the normal requirement.

The efficiency of the motor is reduced as the speed is reduced, since the loss in the resistor is greater at lower speeds. Speed reduction by armature control is usually selected where:

1. A wide speed range is not required.
2. Close speed regulation is not necessary.
3. Operating time at reduced speed is short.
4. Operating load at reduced speed is small so that the reduced efficiency can be ignored.
5. The rating is less than 1 hp.

By proper field, and armature voltage control, motors are available for speed ranges of 8:1 to 16:1 in sizes up to 30 hp. Below basic speed the motors are rated at constant torque and speed control is obtained by armature voltage control. Above basic speed, speed variation is obtained by field control and the motors are rated at constant horsepower. The motors will operate continuously, without injurious temperature rise, in normal ambient, to a speed of one-sixth of basic speed. Below one-sixth basic speed, motor should be operated intermittently only, because of reduced ventilation at the lower speed.

Varying Speed motors are series wound and the speed varies with the load on the motor. They should be used where: (1) the load is practically constant or increases with speed, and (2) the motor can easily be controlled by hand. They should not be used where there is a possibility of operation without load or at a reduced load, as the speed of the motor may become dangerously high.

For shunt wound motors with full field strength, the starting torque varies almost directly with the starting current, which is dependent on the resistance in the armature circuit. With varying positions of the starting rheostat, it is possible to obtain a wide range of starting torque, within the limits of starting current permitted by the power company.

A compound wound motor requires somewhat less current for the same starting torque. The maximum torque of shunt, series, and compound wound motors is limited by commutation.

ALTERNATING CURRENT MOTORS

Alternating current motors may be divided into two principal classifications, namely, (1) those motors which may operate on single phase

current, and (2) those motors which may operate on polyphase current.

1. Single phase motors are available in four common types:
 - a. Capacitor motors.
 - (1) Capacitor start, capacitor run.
 - (2) Capacitor start, induction run.
 - b. Repulsion induction motors.
 - c. Repulsion start, induction run motors.
 - d. Split phase motors.
2. Polyphase (2 or 3 phase) motors are available in three common types:
 - a. Squirrel-cage induction motor.
 - b. Wound rotor induction motor.
 - c. Synchronous motor.

Where the public utility supplying the current determines that a particular installation should be served with polyphase current, it is generally understood that the major portion of the motors will be for polyphase current, although it is commonly acceptable for the smaller motors to be single phase. This will in general limit the use of single phase current to the smaller motor ratings and the polyphase to the larger motors. Domestic and semi-commercial installations will usually be single phase.

Single Phase Motors

Capacitor type motors are available in ratings up to 5 hp for general purposes. These motors are recommended for pumps, compressors and fan duty including housed centrifugal fans and propeller fans. The general purpose motor is commonly known as a high torque capacitor motor having approximately 300 per cent starting torque with normal current and having a different value of capacitance for starting and running which is automatically changed over by a mechanical or electrical means.

Capacitor motors for *fan duty* are usually divided into the open high torque type for belted fans and the totally inclosed non-ventilated low torque type for propeller fans mounted directly on the motor shaft. The open low torque capacitor motor may be used with small centrifugal fans mounted on the motor shaft.

Although the motors for *belted fans* are called high torque, the available starting torque is somewhat less than the torque of the general purpose motor and the slip at full load is approximately 8 per cent. With this larger amount of slip, adjustable speed down to 60 or 70 per cent of rated speed may be obtained by line voltage variation. Motors for *propeller fan* drive may be supplied with sleeve bearings to obtain greater quietness in the smaller sizes where the fan thrust does not exceed approximately 25 lb. For larger fans, thrust ball bearing motors should be used. Low torque capacitor motors have approximately 50 to 60 per cent starting torque and do not change the value of capacitance from start to run. Two of the curves in Fig. 1 show the relation of torque and speed for the low and high torque capacitor motors.

Capacitor motors with *high slip* may have taps brought out from the main winding which, when connected to the line, give a second speed of

from 65 to 70 per cent of the normal speed. This type of motor must be specially designed for the individual fan, otherwise the correct low speed will not be obtained. Care should be exercised in applying it to centrifugal fans where restriction to the air flow through the use of adjustable dampers changes the motor load and consequently the speed. This same effect is also found in transformer speed controllers, however, a series of transformer taps allows for a selection which partially overcomes the effect of change in motor load.

Capacitor start-induction run motors are usually confined to the smaller horsepower ratings and differ from the capacitor motors by having no running capacitor. The value of starting capacitance used may vary with the different types of applications involved. These motors may be used for practically any of the applications met in air conditioning. However,

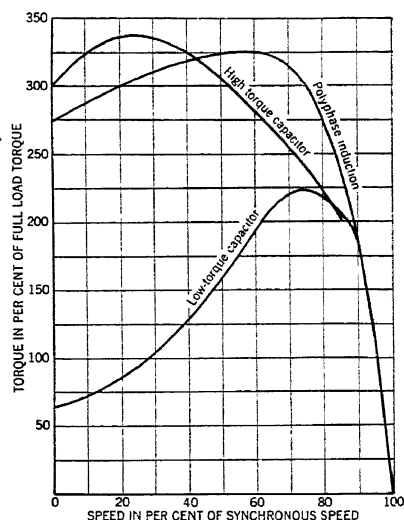


FIG. 1. TYPICAL SPEED-TORQUE CURVES FOR SMALL MOTORS

consideration should be given to the fact that they are not as quiet as a capacitor motor.

Repulsion induction motors start as repulsion motors and operate under full speed as combined repulsion and induction motors through the inherent characteristics of the motor which has, in addition to the wire winding with commutator, a buried squirrel-cage winding. No additional switching devices are required to change over from start to run. This and the repulsion motor described later may be used for constant speed drives where high starting torque is required and where commutator and brush noise is not a factor.

The *repulsion start-induction run* motor starts as a repulsion motor, has a switching means for transferring from start to run which short circuits the commutator and permits operation under full speed as a wound induction motor. This motor is suitable for applications similar to those for which the repulsion induction motor is used.

The *split phase* motor has a high resistance auxiliary winding in the

circuit during starting which is disconnected through the action of a centrifugal switch as the motor comes up to speed. Under running conditions, it operates as a single phase induction motor with one winding in the circuit. These units are available for the lower horsepower ratings and when equipped with a high slip rotor may be used for adjustable varying speed through line voltage control.

Polyphase Motors

Squirrel-cage induction motors are available in four types, three of

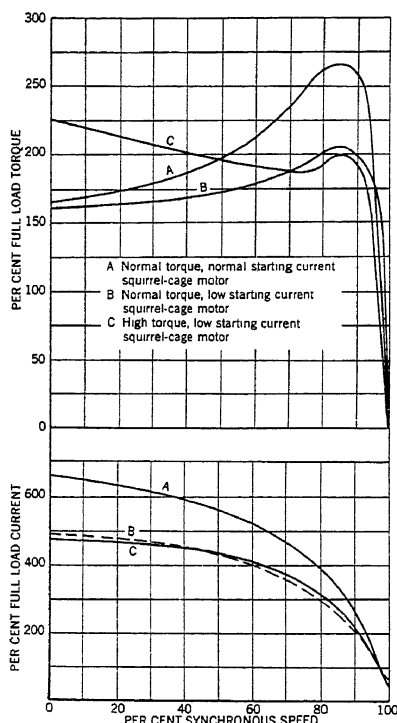


FIG. 2. COMPARATIVE CURVES OF SQUIRREL-CAGE INDUCTION MOTORS

which are normally used in heating, ventilating, and air conditioning applications, and in a full range of sizes:

1. The normal torque, normal starting current squirrel-cage motor has close speed regulation, high efficiency, high power factor, medium starting torque, high pull-out torque, and is suitable for general purpose applications. This motor has a large current inrush and a low starting power factor. When central stations require current limiting starting equipment on such motors, the starting torque is less.

2. The normal torque, low starting current squirrel-cage motor has approximately the same torque as the normal current motor, but the starting current is about 20 per cent less than the normal torque motor on full voltage and ordinarily within most power companies locked rotor current limits on sizes up to 30 hp.

This motor lends itself to automatic or remote control because no current limiting starting equipment is necessary up to and including 30 hp. A magnetic starter with low voltage and thermal relay overload protection gives the most satisfactory service.

3. The high torque, low current squirrel-cage motor has a starting torque approximately 25 to 50 per cent greater than the normal torque motor on full voltage with starting current approximately equal to the normal torque low starting current motor started on full voltage and within the required limits on 30 hp sizes and smaller. These motors are also started directly across-the-line on full voltage through a magnetic starter or other approved starting device.

Typical speed torque and speed current curves for the three types of motors in the integral horsepower size are shown in Fig. 2. A speed torque curve for a fractional horsepower size motor of the polyphase

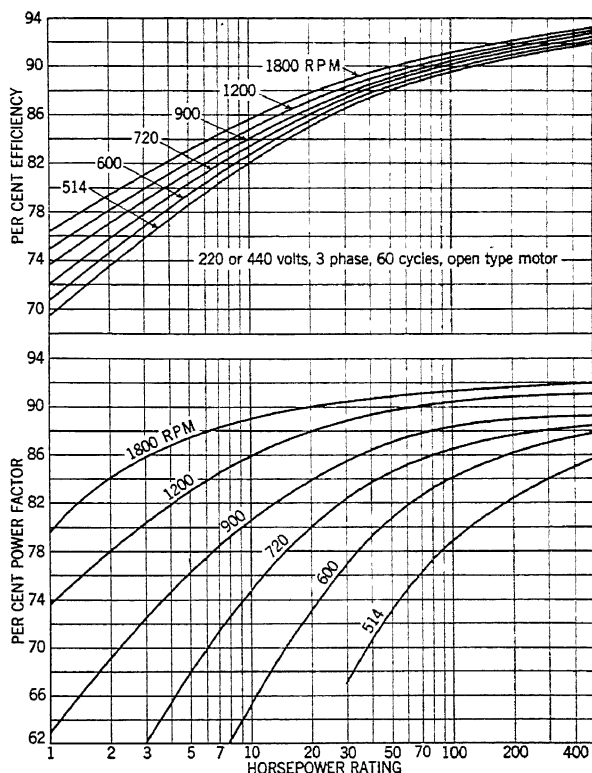


FIG. 3. EFFICIENCIES AND POWER FACTORS FOR SQUIRREL-CAGE INDUCTION MOTORS

type is given in Fig. 1. Some of the motor manufacturers have taken definite steps to combine the normal torque, normal starting current motor, with the normal torque low-starting current motor, and supplying one type of motor with normal torques and a starting current between the normal and low-starting current values now used.

These three types of motors are also available in two, three, or four speed designs with variable torque, constant torque, or constant horsepower characteristics. Two speed motors may be either single, or two winding; three speed motors are two winding; and four speed motors are two winding. When a motor can be wound with a winding for each speed, better operating characteristics may be obtained because no

sacrifice is made for the other speed and operating characteristics approaching single winding motors may be expected.

Frequently, multispeed motors lend flexibility to an installation that cannot be obtained in any other way.

Multispeed motors are started directly across the line through magnetic starting equipment with overload and low voltage protection and may have compelling relays to insure starting on low speed regardless of the ultimate running speed. Starting on low speed limits the starting current to the starting current of the low speed winding and consequently lowers the maximum demand.

Often where the central station requires current limiting starting equipment for the normal torque, normal starting current motor, it is advisable to use the normal torque low starting current multispeed, or the wound rotor motor. High slip polyphase motors may be used for adjustable varying speed drives in a manner similar to that described for

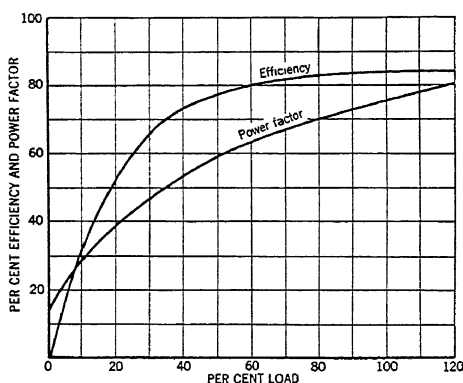


FIG. 4. VARIATION OF EFFICIENCY AND POWER FACTOR WITH LOAD FOR SQUIRREL-CAGE INDUCTION MOTORS

capacitor motors, with either a transformer speed regulator or tapped motor windings.

The approximate full load efficiencies and power factors for general purpose normal torque, normal starting current squirrel-cage induction motors are shown in Fig. 3. The change of efficiency and power factor of a typical normal torque, normal starting current squirrel-cage induction motor with load is illustrated in Fig. 4. The efficiency of a normal torque, low starting current motor is essentially the same as shown in Fig. 3 and the power factor slightly lower. For the high torque low starting current motor the efficiency is considerably lower than Fig. 3 and the power factor slightly lower than shown. It is apparent from these motor characteristics that a squirrel-cage motor may be selected for operating any air conditioning and allied equipment.

Some *polyphase induction* motors are constructed with two windings on the rotor, one of which is a high resistance, squirrel-cage winding used in starting and gives a high starting torque approximately the same as the high torque, squirrel-cage. A centrifugal mechanism within the motor switches to the second low resistance winding when the motor

comes up to speed, thus obtaining running characteristics equal to the normal torque, normal current squirrel-cage motor. The starting power factor of the motor is high.

Wound rotor motors are built for two classes of service, constant speed and adjustable variable speed. The motors are identical in each case and use the same primary control, the only difference being in the secondary control. Wound rotor motors for constant speed service are used where high starting torque with low starting current is required for bringing heavy loads up to speed. The resistance is in the secondary or rotor circuit, only when starting, and is short circuited when the motor is up to speed.

For adjustable varying speed service, part or all of the secondary

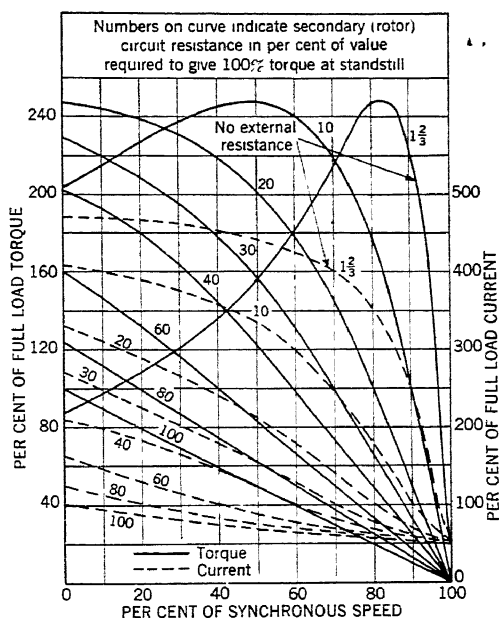


FIG. 5. PERFORMANCE CURVES FOR WOUND ROTOR MOTOR WITH DIFFERENT EXTERNAL RESISTANCES

controller resistance is in the circuit whenever the motor is operating below full speed. The speed obtained with a given resistance in the secondary circuit is dependent on, and changes within limits, with the load on the motor. The horsepower developed by the motor driving a load requiring constant torque, such as a reciprocating compressor, is approximately proportional to the speed, whereas the power input required by the motor is practically the same at reduced speed as at full speed. Hence the efficiency at reduced speed is much lower than at full speed. For such a motor the minimum speed is approximately 50 per cent of the full load speed. For loads whose torques decrease with speed, such as fans and blowers the horsepower developed is approximately proportional to the cube of the speed and the power input to the motor is reduced with decreased speed. However, the efficiency is lower than full

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TABLE 1. CLASSIFICATION OF MOTORS

CURRENT	TYPE	SPEED CHARAC- TERISTICS	FULL VOLTAGE		HP RANGE	TYPE OF APPLICATION SEE FOOTNOTE*
			STARTING TORQUE	STARTING CURRENT		
Constant Speed Drives						
DIRECT	1. Shunt	Constant	Normal	Normal	All	(a) Fans and (c) centrifugal pumps and centrifugal compressors
	2. Compound	Constant or Variable	High	Normal	All	(b) (c) (e) Reciprocating pumps and fre- quent or hand starting
	3. Series	Variable	High	Normal	Small	(d) Fans direct con- nected
POLY- PHASE	4. Squirrel-Cage General Purpose Normal Torque	Constant	Normal 0.8-1.5 times	High 6-8 times	All	(a) Fans and (c) centrifugal pumps and centrifugal compressors
	5. Squirrel-Cage Normal Torque	Constant	Normal 0.8-1.5 times	Normal 5-6 times	Medium Small	(a) Fans and centri- fugal pumps and centrifugal com- pressors
	6. Squirrel-Cage High Torque	Constant	High 2-2.6 times	Normal 5-6 times	Medium Small	(b) Reciprocating pumps (e) and compressors started loaded
	7. Wound Rotor	Constant or Variable	High 1-2.5 times	Low 1-3 times with sec- ondary control	All	(a) Hoists (b) reciprocating pumps and com- pressors (c) and frequent (e) or hand start
	8. Synchronous High Speed	Constant	Normal 0.75-1.75 times	Normal 5-7 times	Medium Large	(a) Fans and centri- fugal pumps and centrifugal com- pressors
	9. Synchronous Low Speed	Constant	Low 0.3-0.4 times	Low 3-4 times	Medium Large	(a) Reciprocating compressors start- ing unloaded
SINGLE PHASE	10. Capacitor	Constant	High	Normal	Small	(b) Pumps and compressors
	11. Capacitor Fan	Constant	Normal	Normal	Small	(a) Fans, centrifugal pumps

*Applications:

a. Drives having medium or low starting torque and inertia (WR^2) such as fans and centrifugal pumps or reciprocating pumps and compressors started unloaded.

b. Drives having high starting torques, such as reciprocating pumps and compressors started loaded.

c. Similar to (a) except where frequent or hand starting (large WR^2) requires a higher starting and accelerating torque.

d. Fans direct connected.

e. Stoker drives.

CHAPTER 36. MOTORS AND MOTOR CONTROLS

TABLE 1. CLASSIFICATION OF MOTORS—(Concluded)

CURRENT	TYPE	SPEED CHARAC- TERISTICS	FULL VOLTAGE		HP RANGE	TYPE OF APPLICATION SEE FOOTNOTE*
			STARTING TORQUE	STARTING CURRENT		
SINGLE PHASE	12. Capacitor Start Induction Run	Constant	High	Normal	Small Fractional	(a) Fans (b) pumps and compressors
	13. Repulsion Induction	Constant	High	Normal	Medium Small	(a) Fans (b) pumps and compressors
	14. Split Phase	Constant and Adjust- able	Normal	Normal	Fractional	(a) Fans (b) pumps and compressors (d) fans—direct

Adjustable Speed Drives

DIRECT	15. Shunt Field Adjustment	Constant	Normal	Normal	All	(a) Fans and (c) centrifugal pumps
	16. Shunt Armature Resistor	Variable	Normal	Normal	All	(a) Fans and (c) centrifugal pumps
	17. Variable Voltage Control	Variable	Normal	Normal	All	(d) Fans and centrifugal pumps
POLY- PHASE	18. Squirrel-Cage High Slip, Transformer Adjustment	Variable	Normal	Normal	Medium Small	(a) Fans
	19. Squirrel-Cage Separate Wind- ing or Regrouped Poles	Constant Multi- Speed	Normal or High	Normal or Low	All	(a) Fans (b) pumps and (c) compressors
	20. Wound Rotor, External Secondary Resistance	Variable	High	Low	All	(a) Fans (b) centrifugal pumps and compressors
SINGLE PHASE	21. Repulsion	Variable	High	Normal	Low and Fractional	(a) Fans—centrifugal pumps (b) compressors
	22. Capacitor Low Torque Tapped Winding	Variable Two Speed	Low	Normal	Fractional	(d) Fans, direct
	23. Capacitor Low Torque Trans- former Adjust- ment	Variable	Low	Low	Fractional	(d) Fans
	24. Split Phase Regrouped Poles	Constant	Normal	Normal	Fractional	(d) Fans

load efficiency. For loads with greatly lower horsepower requirements at reduced speed motors can be furnished with minimum speeds of 25 per cent of maximum speed.

The curves of Fig. 5 indicate the performance of a typical wound rotor motor with various values of secondary or external resistance. With various values of resistance the motor will operate with different speeds below full load speed, depending on the load torque. By use of a suitable resistor the motor can be operated continuously at reduced speed.

Synchronous motors are ordinarily used where there is a need for or advantage in obtaining power factor correction and high efficiency, or where constant speed is necessary or where they have a lower first cost than other types of motors. They are especially applicable for large low speed reciprocating compressor drive in view of their lower first cost. It is necessary to consider each application as a special case, which must be individually engineered to correctly establish the combined moment of inertia of the compressor, compressor flywheel and motor rotor. Otherwise due to the torque pulsations of the compressor unsatisfactory operation will result.

Synchronous motors are frequently used for driving large direct connected, medium speed fans where continuous operation makes high efficiency and power factor of some value. Similarly they are being used for driving large high speed centrifugal compressors through speed increasing gears. On this type of compressor, the torque characteristics are the same as for a fan and each application is not a special case as is true for reciprocating compressors.

Other means of obtaining adjustable speed drives is by using a constant speed motor either induction or synchronous type, and an adjustable speed coupling. These couplings are available in both hydraulic and magnetic types, both of which are easily adjustable over a wide speed range with a variable torque load and a more moderate speed range with a constant torque load.

Enclosures

Motors are built in several types of frames depending on the particular application. Usually the open type of motor, meaning one with an open frame so that the windings are not too closely protected from ambient conditions such as dirt, dust, moisture, abrasive material, etc. is used. In case the motor is to be installed under dripping pipes, for instance, a drip-proof frame motor should be used and in case the motor is to be exposed to splashing water a splash-proof frame motor should be used. These types of frames offer more protection to the motor winding and consequently the winding experiences a reasonable life. Similarly if the motor is to be exposed to abrasive dust or explosive gases special enclosed or explosion proof frames should be considered. Such requirements as these are frequently encountered in certain industrial applications in which cases, it is necessary to select the motors from the viewpoint of service conditions as well as the required operating and temperature characteristics to meet the demands of the machines being driven and the surrounding ambient.

The general classification of motors used for heating, ventilation and air conditioning is shown in Table 1.

CONTROL EQUIPMENT FOR MOTORS

In selecting control for alternating and direct current motors it is necessary to determine whether the installation is to be operated by manual or automatic control. The available controls and the function of each group of apparatus may be outlined as follows:

1. Manual Control:
 - a. To establish current.
 - (1) Snap switch.
 - (2) Knife switch.
 - (3) Manually operated contactor.
 - (4) Drum switch.
 - b. Establish current and provide overload protection.
 - (1) Snap switch with overload element.
 - (2) Knife switch with fuse or thermal cutout.
 - (3) Manual contactor with overload protective device; also reduced voltage starting compensator.
 - (4) Drum switch with overload protection.
 - c. Establish current and provide overload and low voltage protection.
 - (1) Not used.
 - (2) Not used.
 - (3) Manual contractor or reduced voltage compensator with overload and low voltage release.
 - (4) Drum switch equipped with latch coil to give low voltage release.
2. Automatic Control:
 - a. To start on full voltage.
 - (1) Without overload device (used only on small fractional horsepower motors).
 - (2) With overload device.
 - (3) With combination overload device and disconnect switch.
 - (4) With combination overload device, disconnect switch and short circuit protection.
 - b. Reduced voltage starting with options, 2, 3 and 4, under full voltage control.
 - (1) Primary resistance type starter.
 - (2) Auto transformer type.
 - (3) Reactor type.

The present trend in practice is to include short circuit protection for the motor feeder and controller in the automatic starter either by means of fuses or breakers depending on the size and voltage of the motors, and the short circuit capacity of the feeders and source of power to which the motors are connected.

Most motors are mechanically and electrically designed for full voltage starting. Power companies have set up certain restrictions on starting motors on full voltage due to the necessity of maintaining voltage on their distribution lines within certain limits. Large motors on low voltage systems may cause serious voltage dips on starting, due to the high value of the inrush current. However, certain types of motors such as those with switches for changing the motor circuit during the starting period, may draw other high peaks of current as large or larger than the initial inrush, during the accelerating period which will also cause voltage dips. These voltage dips may cause light flickering, shortening of lamp

life and other objectionable results. To avoid these effects reduced voltage starters are used. However, the starting limitations vary with the various power companies and the starting requirements should be checked in each locality.

PILOT CONTROLS

In selecting pilot control devices to operate in conjunction with either manual or automatic motor control, it is necessary that they be classified as follows:

1. *Two Wire Control.* Some thermostats, float switches, and pressure regulators provide two wire control which gives low voltage release. A three position off-on automatic pilot switch can be used in connection with this method and thus provide manual control. With a low voltage (12 or 20 volt) control circuit it is desirable to use a low voltage thermostat. When this type of thermostat is used it will be found that a saving in the wiring cost results. When using the low voltage thermostat on a control circuit a relay and transformer panel should be used instead of the low voltage coil on the starter.

2. *Three Wire Control.* Other types of thermostats, float switches and pressure regulators are of the three wire, low voltage type and are used in conjunction with a control circuit relay for controlling the operation of motors. Momentary contact start and stop push button stations are usually furnished as standard accessories with automatic starters, which give low voltage protection. This control cannot be used in combination with two wire pilot devices.

In selecting manual control for an alternating or a direct current motor, the common practice is to locate the control near the motor. When the control is installed at the motor, an operator must be present to start and stop or change the speed of the motor by operating the control mechanism. Sometimes manual control is employed only as a device to give overload protection and another device is employed to start and stop the motor. Manual control is used particularly on small motors which operate unit heaters, small blowers, and room coolers in an air conditioning system. In other cases manual control in the form of drums, when used with multispeed motors, is only used as a speed setting device with the starting and stopping functions operated automatically through thermostats, and pressure switches.

Because of the increasing complexity of air conditioning systems, heating, ventilating and air conditioning equipment is being operated on automatic control with less dependence on manual operation and regulation.

Automatic control of motor starters may be accomplished by the use of remote push button stations, by a thermostat, float switch, pressure regulator or other similar pilot devices. An added advantage of automatic control is that the main wiring for the starter may be installed near the motor, while the starter may be operated by a control device located elsewhere. In the majority of air conditioning installations, requiring motors 1 hp and larger, two or three phase alternating current is usually supplied.

DIRECT CURRENT MOTOR CONTROLS

Air conditioning installations using direct current power now are used only where alternating current is not available. Direct current motors

are always started through starters, which are devices using a resistance to be put in series with the armature circuit during starting only, the resistance being gradually cut out as the motor comes up to speed. The starting current is held within safe limits by the use of the resistance. The speed of a direct current motor may be regulated by several methods:

1. Speed adjustment by field control—by using a device with resistance to be put in series with the field winding. After the motor has been started to be used to increase the speed of the motor above full field speed.

2. Speed adjustment by armature control—by using devices with resistance to be put in series with the armature circuit to be used to reduce the speed of the motor below full field or normal speed.

3. Combinations of field and armature control, so that the starting, field control, or armature control may be combined in a single unit.

4. Speed adjustment by variable voltage control—by using a source of variable voltage a wide speed range from 16:1 and less can be obtained. Speed above basic motor speed is obtained by field control and below by reduced armature voltage. In the smaller range of motor sizes complete equipments are available for this type of control. In the ranges up to 30 hp this is accomplished by a small motor generator set. Below $7\frac{1}{2}$ hp variable voltage speed control can be obtained through the use of electronic tubes for rectification and control functions.

Field control is usually preferred, depending on the size of the installation. For example, if a direct current motor were required with speed regulation between 1200 and 600 rpm, a choice of supplying a 1200 rpm motor with armature control or a 600 rpm motor with field control, both giving the same speed variation would be possible. While the 1200 rpm motor with armature control is lower in first cost than the 600 rpm motor with field control, the cost of operating the 600 rpm motor with field control is less and will save the difference in first cost over a period of time depending on the size of installation. A wide speed variation can be easily obtained in a direct current motor by using a combination of field and armature control.

SQUIRREL-CAGE MOTOR CONTROL

To meet the requirements of various drives of an air conditioning system, three types of squirrel-cage, two or three phase motors may be used: (1) normal torque, normal starting current, (2) normal torque, low starting current, and (3) high torque, low starting current.

Because of the large current inrush of the normal torque, normal starting current motor, some central stations usually require current limiting starting equipment on such motors above $7\frac{1}{2}$ hp. To meet the starting current requirements, manual or automatic current limiting reduced voltage controllers are used. These controllers are equipped with voltage taps, the 65 per cent tap being regularly furnished when the starter leaves the factory. Motors $7\frac{1}{2}$ hp and smaller have starting currents within the requirements of central stations and manual or magnetic, full voltage control may be used in all cases.

The normal torque, low starting current motor has a starting current which is approximately 20 per cent less than the normal current motor on full voltage and within the required current limits on 30 hp sizes and smaller. This motor, therefore, lends itself to across-the-line control because no current limiting equipment is necessary.

A magnetic starter with low voltage and thermal overload protection gives the most satisfactory service. These starters may be controlled by remote push button stations, thermostats, or pressure switches to meet the requirements of any particular installation.

The high torque, low starting current motor has a starting current approximately the same as the normal torque, low starting current motor when started on full voltage. These motors, most commonly used on compressor drive, can be started directly across-the-line with manual or magnetic starters.

MULTISPEED MOTOR CONTROL

To make an installation more flexible, multispeed motors are available with two, three or four speed designs, with variable torque, constant torque or constant horsepower characteristics. Multispeed motors may be started by means of manual or magnetic starting equipment.

When using automatic magnetic control with two, three, and four speed separate winding or consequent pole motors, control is obtained from a remote point by means of a push button master switch. The various speeds of the motor are obtained from the master switch by simply depressing the correct push button, which is known as selective speed control. It is commonly used in the smaller theater installations where the fan and motor are located backstage and the speed control is located in the lobby.

Magnetic multispeed motor controllers may also be provided with a compelling relay which makes it necessary that the operator press the first speed button before regulating the motor to the desired speed. This assures the operator that the motor is always started at low speed before the motor is adjusted to one of the higher speeds. Starting on low speed limits the starting current to the starting current of the low speed winding, and therefore, permits the use of motors in sizes larger than ordinarily permitted by central stations for full voltage starting.

Timing relays, which provide for automatic acceleration, may be used for control. With the automatic acceleration feature, it is only necessary to press the button for the desired speed. The motor will always start in low speed and automatically step up to the desired speed. Decelerating relays are used on multispeed compressor motors, in order to reduce the effect of the braking action and shock to the motor, compressor and drive, when the speed is to be reduced from a higher to a lower speed.

Where the change of speeds does not occur at regular intervals, and where it is only necessary to change from one speed to another to take care of seasonal requirements, a manual drum speed selector may be used. This drum is used to select the proper motor speed while an automatic starter is used to start and stop the motor.

The smaller size speed selector drums rated 10 hp at 220 volts and smaller may also be used as a motor starter to make and break the current, as well as serving as a speed selector device. Reversible or non-reversible drums may be supplied depending on the requirements of the installation.

In the large size drums, a separate contactor must be provided to make and break the current. The contactor may be any approved starter.

Overload and low voltage protection may be accomplished by using a magnetic starter. No push button station is required, the handle switch on the drum having the same characteristics as a three wire push button station.

In selecting two speed motors for fan, pump, blower, or compressor drive it will be found that the two winding motors are more expensive than the single winding. The control for two speed, two winding motors is more economical and the combined price of the motor and contactor is only slightly higher. Because of the better performance of the two speed motor and the factor of safety in having two independent motor windings, the increased cost is considered worth the difference.

WOUND ROTOR MOTOR CONTROL

When close speed regulation and low starting current are required slip ring or wound rotor motors are used. Wound rotor induction motors are built for two classes of service, constant speed and adjustable varying speed. The motors for the two classes of service are identical, the only difference being in the secondary control used with the motors. Control for both primary and secondary of a slip ring motor is required.

The primary control for a constant or adjustable speed is the same type as used with squirrel-cage motors. Manual or magnetic starters, across-the-line type, may be used depending on the installation.

The starting current and starting torque of a slip ring motor are almost entirely dependent on the amount of resistance in the secondary control and in the manner in which the secondary control is operated. The resistance for the secondary control is usually of the cast-iron grid construction and the amount of the resistance in the circuit is controlled by a multi-point drum or cam switch which can be manually or automatically positioned. The *National Electric Manufacturers Association* has adopted service classifications which allow a selection of resistors permitting a starting current on the first contact of resistance varying from approximately 25 per cent of full load current to approximately 200 per cent of full load current or more, and permitting the resistor to remain in the secondary circuit of the motor for a period varying from not more than 15 seconds during an interval of operation from 4 minutes to continuous.

Speed adjustment of a wound rotor induction motor is obtained by inserting resistance in the secondary circuit and usually provides for a 50 per cent speed reduction when the motor is selected for constant torque service for full load at maximum speed. For variable torque duty, such as fans drives, wound rotor motors and control are suitable for speed reduction to 25 or 30 per cent of full load speed. As resistors are supplied for both fan duty and constant torque duty, care should be taken in selecting the proper resistors.

Wound rotor induction motors when used with centrifugal pumps and fans should have fan duty resistors. Because of the low current inrush of the fan and pump load a starting resistor *NEMA* classification No. 15 may be used. For speed regulation resistor, classification No. 93 should be selected. On a compressor drive using an unloader, a constant torque resistor classification No. 15 should be used. If the compressor is started

under load, *NEMA* classification No. 56 or 76 is used. For constant torque speed regulation, resistor No. 95 is used.

Liquid rheostats for secondary control, suitable for starting and speed variation are available where an infinite member of speeds are required. The cost of the liquid rheostat are comparable to the conventional cast grid and cam switch construction in the larger sizes but more expensive in the smaller. The liquid rheostats are suitable for either constant or variable torque drives but are not satisfactory for cold ambient conditions, where the electrolyte could freeze during periods of non-operation. The amount of resistance in the circuit can be manually or automatically controlled.

SINGLE PHASE MOTOR CONTROL

Where three phase current is not available or where single phase operation is preferred, then single phase repulsion induction, capacitor type or multispeed single phase motors may be used. Since the starting currents of all single phase motors are required to be within the starting-current limits established by the local power supply company, a suitable type of starter may be chosen from the following selection:

1. Enclosed two pole manually operated motor starters with thermal overload protection.
2. Enclosed two pole automatic motor starter operated by a push button, thermostat or similar device, with thermal overload relay and low voltage protection.
3. A manual or magnetic resistance type starter with low voltage protection.
4. A manual or magnetic control for pole changing motors and for adjustable varying speed motors using an auto-transformer or resistance in the primary circuit to obtain line (or terminal) voltage drop.

In selecting across-the-line control for single phase capacitor type motors it is usually very desirable to use three pole across-the-line starters. Control for multispeed, single phase capacitor motors may be selected from tables on three phase rating when consideration is given to the increased current and the necessary switching of connections.

Chapter 37

AIR CONDITIONING IN THE TREATMENT OF DISEASE

Operating Rooms, Reducing Explosion Hazards, Nurseries for Premature Infants, Fever Therapy, Cold Therapy, High Temperature Hazards, Control of Allergic Disorders, Oxygen Therapy, General Hospital Air Conditioning

IN the past few years air conditioning has made considerable progress as an adjunct in the treatment of various diseases. Among the important applications are those in operating rooms, nurseries for premature infants, maternity and delivery rooms, children's wards, clinics for arthritic patients, heat therapy, cold therapy, oxygen therapy, X-ray rooms, the control of allergic disorders, and for the physiological effects in industry.

OPERATING ROOMS

The widest application of air conditioning in hospitals is in operating rooms. Complete air conditioning of operating wards is important because winter humidification helps reduce the danger of anesthetic gases; summer cooling with some dehumidification is needed to eliminate excessive fatigue and to protect the patient and operating personnel; and finally, filtering for the removal of allergens from the operating room air.

Reducing Explosion Hazard

Explosion hazards in operating rooms began with the introduction of modern anesthetic gases and apparatus. Ether administered by the old drop method is still regarded as comparatively safe; but when mixed with pure oxygen or with nitrous oxide in certain concentrations the explosion hazard may be as great as with ethylene-oxygen, or cyclopropane-oxygen mixtures¹. (See Table 1.)

During the course of ethylene anesthesia, the mixture, usually 80 per cent ethylene and 20 per cent oxygen, is so rich that the danger of explosion is slight in the immediate vicinity of the face mask, but leakage of ethylene into the air may accumulate to any lower concentration, and thus introduce a serious hazard. The most dangerous period is at the end of the operation when the patient's lungs and the anesthesia apparatus are customarily *washed out* with oxygen with or without the addition of

¹Safeguarding the Operating Room Against Explosions, by Victor B. Phillips (*Modern Hospital*, 46, April and May, 1936)

carbon dioxide. Even when this procedure is omitted, it is difficult in practice to avoid dilution of the anesthetic gas with air during the normal course of breathing following the administration. In either case the mixture would pass through the explosion range and extraordinary precaution is necessary for the safety of the patient and operating personnel.

Copious ventilation from 6 to 12 air changes per hour reduces to some extent the danger from the open drop method but is of little value in the closed system type of anesthetic machine now in common use. However, this abundant circulation reduces the concentration of anesthetic gases to below the physiologic threshold so that the surgeon and his personnel will not be affected.

The most important cause of accidents is probably static sparks which may result from accumulation of frictional charges on the rubber surfaces of the anesthesia apparatus, on woolen blankets, and on the bodies of the operators as they walk on insulated floors, when the humidity is low. Grounding the various parts of the anesthesia apparatus is not entirely

TABLE 1. EXPLOSIVE PROPERTIES OF ANESTHETICS^a

ANESTHETIC	FORMULA	DENSITY AIR = 1	LIMITS OF INFLAMMABILITY			
			IN AIR		IN OXYGEN	
			Lower	Upper	Lower	Upper
Ethylene.....	C_2H_4	0.97	2.75	28.6	2.90	79.9
Propylene.....	C_3H_6	1.45	2.00	11.1	2.10	52.8
Cyclopropane.....	C_3H_6	1.45	2.40	10.3	2.45	63.1
Nitrous Oxide.....	N_2O	1.52	-----	-----	Not Inflammable	
Ethyl Chloride.....	C_2H_5Cl	2.23	4.00	14.8	-----	-----
Ether-divinyl.....	$(C_2H_5)_2O$	2.42	1.70	27.0	1.85	85.5
Ether-diethyl.....	$(C_2H_5)_2O$	2.56	1.85	36.5	2.10	82.0
Chloroform.....	$CHCl_3$	4.12	-----	-----	Not Inflammable	

^aExplosion and Fire Hazards of Combustible Anesthetics (*U. S. Bureau of Mines*, Report of Investigations No. 3443, April, 1939).

effective, so long as rubber remains in use in the conventional equipment. Some form of protective grounding within the apparatus may be a partial solution.

A comprehensive study of the explosion problem and of the general causes and prevention of operating room hazards is being conducted by the *University of Pittsburgh*, the A.S.H.V.E. Research Laboratory, and the *U. S. Bureau of Mines*. The first result of this investigation has been a fruitful attempt to eliminate the explosive range of cyclopropane, one of the best but most difficult gases to handle. The use of helium as a diluent in the total gaseous mixture controls the oxygen concentration by replacement and since its flame quenching qualities are known it is the ideal gas for this purpose. In addition, a gaseous mixture containing helium is more difficult to ignite by electric discharges and this quality also increases the safety factor of anesthetic administration. A more general idea of the mixtures containing cyclopropane, oxygen and helium necessary to produce satisfactory anesthesia is given in Table 2. Clinically and with slight variation, the non-inflammable mixtures of Table 2

have produced satisfactory results and samples of gas taken during operation show no tendencies to explosion.

In the absence of more understanding, no single safeguard can be given, but desirable precautions may be classed as follows: (1) to limit the region of the explosive gas mixtures; (2) to make all electric contacts explosion-proof; (3) to avoid building up static charges; (4) to ground those surfaces where charges may be built up; and (5) to discourage accumulation of static electrical charges by humidity control.

Operating Room Conditions

Little is known about optimum air conditions for maintaining normal body temperatures during anesthesia and the immediate post-operative period. An anesthetized patient displays dilatation of blood vessels in the skin resulting in profuse sweating and (it has been believed) inability to regulate body temperature. From this it was concluded that all anesthetized patients suffered considerable heat loss. In spite of this a recent paper² reports little more than 0.8 F variation in the rectal temperature during the course of the operation. The severe physiological

TABLE 2. NON-INFLAMMABLE MIXTURES FOR ANESTHETIC USE^a

MIXTURE No.	COMPOSITION, PER CENT BY VOLUME		
	Cyclopropane	Oxygen	Helium
1	15	20	65
2	20	20	60
3	25	25	50
4	30	30	40

^aExplosive Properties of Cyclopropane: Prevention of Explosions by Dilution with Inert Gases (*U. S. Bureau of Mines, Report of Investigations No. 3511, May, 1940*).

effects, such as excessive sweating and rapid pulse, of high operating room temperatures on attendants and patients during the hot months signify the need for proper cooling. A comparison of surgeons' statements who operate in both air conditioned and non air conditioned rooms strongly indicates lesser fatigue; and the greater recuperative power of the patient is confirmed by the previously referred to study³.

Although the comfortable air conditions for the operatives are not identical with those for the patient a compromise is as a rule not difficult; with a relative humidity of 55 to 60 per cent, temperatures from 72 to 80 F are used. The work just cited, reported that 68 to 70 deg effective temperature not only furnished comfort for the operating room workers but apparently prevented exhaustion of the patient as evidenced by rapid convalescence in the recovery ward. Additional heat may be furnished to the patient locally or by suitable covering according to body temperature in individual cases.

²A.S.H.V.E. RESEARCH REPORT No. 1111—Air Conditioning Requirements of an Operating Room and Recovery Ward, by F. C. Houghten and W. Leigh Cook, Jr. (A.S.H.V.E. TRANSACTIONS, Vol. 45, 1939, p 161).

³Loc. Cit. Note 2.

In an investigation recently conducted at the University of Pittsburgh, in a cooperative research program with the Society, comparative studies were made on the bacterial content of conditioned and non-conditioned operating rooms. From these studies⁴ it was concluded that the bacterial content of conditioned operating rooms was considerably less than that of non-conditioned rooms. Although this difference may not be great it is sufficient to demonstrate that properly conditioned spaces with adequate filtration can definitely reduce the bacterial and other foreign substance content in an enclosure.

Operations may be postponed on allergic patients during asthmatic manifestations through fear of complications. The removal of air borne allergens, therefore, is in some cases an important function of the air conditioning system in preparing patients for operation.

Central system air conditioning plants and unit air conditioners prove satisfactory in operating rooms when producing between 8 and 15 air changes per hour of filtered and properly conditioned air without recirculation during the course of anesthesia. A separate exhaust fan system is as a rule necessary to confine and remove the gases and odors. Double windows are desirable and often necessary to prevent condensation and frosting on the glass in cold weather and to minimize drafts. The high air flow of 8 to 15 air changes in operating rooms is desirable for three reasons: (1) to reduce the concentration of the anesthetic to well below the physiologic threshold in the vicinity of the operating personnel, (2) to remove the great amounts of heat and sometimes moisture, from sterilizing equipment if inside the operating room, from the powerful surgical lights, from solar heat, and from the bodies of the operatives, and (3) to provide extra capacity for quickly preparing the room for emergency operations. Much can be gained by careful insulation of sterilizing equipment and by thorough exhaust ventilation of sterilizing rooms adjoining the operating rooms.

A very common complication presumably traceable to operations is pneumonia. The difference in conditions between the operating room and the final hospital destination of the patient, including corridors and elevators, is conducive to post-operative pneumonia. A suggested remedy is a recovery ward where conditions closely approximate those of the operating room and in which the patients remain from one to four days. Satisfactory conditions in the recovery ward not only hasten convalescence, but dispel the fear frequently found in patients who must undergo operations during the hot seasons⁵.

Sterilization of Air in Operating Room

Of considerable significance to operating rooms and contagious wards is the use of ultra-violet radiation for sterilizing the air⁶. Results reported⁷ would indicate that the post-operative temperature rise of patients

⁴Report on Air Conditioning in Surgery, by W. Leigh Cook, Jr. (Department of Industrial Hygiene, School of Medicine, University of Pittsburgh, 1940)

⁵Report of the Committee on Air Conditioning (*The American Hospital Association*, 1937, p. 2).

⁶Air-Borne Infection and Sanitary Air Control, by W. F. Wells (*Journal Industrial Hygiene*, 17:253 1925).

⁷Sterilization of the Air in the Operating Room by Special Bactericidal Radiant Energy, by Deryl Hart (*Journal Thoracic Surgery*, 6:45, 1936).

during the first few days is in most instances caused more by bacterial contamination of the operative wound than by the absorption of blood and traumatized tissues. Operating room infections, which were quite frequent before the installation of special ultra-violet lamps, are apparently being reduced.

Direct ultra-violet radiation is distinctly advantageous in sterilizing not only the site of operation but also wounds to prevent the spread of infection. In infants' wards, contagious disease wards, and even in school rooms, the sterilizing effects are definitely known. Whether an air conditioning system with ultra-violet installations in the ducts is a feasible procedure is controversial; but it would appear that this indirect method is not as satisfactory as the direct in the light of present reported knowledge.

TABLE 3. NET MORTALITY OF PREMATURE INFANTS ACCORDING TO HUMIDITY^a
Infants Hospital, Boston, Mass.

CAUSE OF DEATH	UNCONDITIONED NURSERIES (1923-1925)	CONDITIONED NURSERIES (1926-1929)	
	NATURAL HUMIDITY	RELATIVE HUMIDITY	
		25-49 Per Cent	50-75 Per Cent
		Per Cent Mortality	Per Cent Mortality
Acute and chronic infections.....	26.5	9.7	0.0
Congenital deformities.....	1.2	0.0	0.7
Unclassified.....	1.2	4.8	0.0
All causes.....	28.9	14.5	0.7

^aExcluding cases with multiple congenital anomalies incompatible with life, and also deaths occurring within 48 hours after admission to the hospital.

NURSERIES FOR PREMATURE INFANTS

One of the most important requirements in the care of premature infants is the stabilization of body temperature. This is because their heat regulating systems are not fully developed; the metabolism is low and the infants generally exhibit marked inability to maintain normal body temperatures. The resistance to infection is low and mortality rate high.

Air Conditioning Requirements

The optimum air conditions for the growth and development of these infants were determined by extensive research⁸ at the Infants Hospital, Boston, Mass., using four valid criteria, namely, stability of body temperature, gain in weight, incidence of digestive syndromes, and mortality. Individual temperature requirements varied widely (from 72 to

⁸The Premature Infant: A Study of the Effects of Atmospheric Conditions on Growth and on Development, by K. D. Blackfan, C. P. Yaglou and K. McKenzie (*American Journal Diseases of Children*, 46: 1175, 1933)

100 F) according to the constitutional state of the infants and body weights. The optimum relative humidity was about 65 per cent, and the air movement less than 20 fpm.

A single nursery conditioned to 77 F and 65 per cent relative humidity was found to fulfill satisfactorily the requirements of the majority of premature infants. Additional heat for weak (or debilitated) infants may be furnished in the cribs or by means of electric incubators placed inside the conditioned nursery, and the temperature adjusted according to individual requirements. In this way multiplicity of chambers and of air conditioning apparatus is obviated; the infants in the heated beds derive the benefit of breathing cool humid air, and the nurses and doctors need not expose themselves to extreme conditions.

Importance of Humidity: Although external heat is an important factor in the maintenance of normal body temperature, humidity appears to be of equal or greater importance. When the premature nurseries at the Infants Hospital were kept at relative humidity between 25 and 50 per cent for two weeks or longer, the body temperature became unstable, gain in weight diminished, the incidence of gastro-intestinal disturbances increased, and the mortality rose. On the other hand, continuous exposure to air conditions with 55 to 65 per cent relative humidity gave satisfactory results over a period of years. The effect of humidity on mortality is shown in Table 3. The initial physiologic loss of body weight (loss occurring within first four days of life) was found to vary inversely with the humidity. In the old nurseries with natural humidity it averaged 12.4 per cent of the birth weight; in the conditioned nurseries it was 8.9 per cent with 25 to 49 per cent relative humidity, and 6.0 per cent with 50 to 75 per cent relative humidity. The number of days required to regain the birth weight was correspondingly maximum in the old nursery and minimum in the conditioned nurseries under high humidity.

Maximum gains in body weight occurred in the conditioned nurseries under high humidity (55 to 65 per cent) in infants weighing less than 5 lb. The gains were less under low humidity (25 to 50 per cent) in the same nurseries, and in the old nurseries prior to the installation of air conditioning apparatus.

The incidence and severity of digestive syndromes, with diarrhea, persistent vomiting, diminishing gain or loss of body weight, and other symptoms, were generally from two to three times as high under low than under high humidity.

Summarizing, the best chances for life in premature infants are created by maintaining a relative humidity of 65 per cent in the nursery and by providing a uniform environmental temperature just sufficiently high to keep the body temperature within normal limits. Medical and nursing care are, of course, factors of equal and sometimes of greater importance.

Air Conditioning Equipment

Most of the installations now in use are of the central system type providing for filtration, for humidification and heating in cold weather, and for cooling and dehumidification in hot weather. A high ventilation rate, between 15 and 25 air changes, is desirable to remove odors and

maintain uniformity of temperatures in extremes of weather. Recirculation is not used extensively in these wards owing to odors and the possibility of infection.

FEVER THERAPY

Artificial production of fever in man is an imitation of nature's way of overcoming invading pathogenic organisms. The action may be direct and specific by destruction of the invading organism within the safe limit of human temperatures, or indirect in the case of heat resistant organisms, by general mobilization of the defensive mechanisms of the body, which retard or neutralize the activity of pathogenic bacteria and their toxins.

The limits of induced systemic fever are usually between 104 and 107 F (rectal), and the duration from 3 to 8 hours at a time. The total period of fever treatment varies with the type of the organism involved from a few hours to 50 or more.

The diseases which respond favorably to artificial fever therapy are gonorrhea and its complications, (which include arthritis, pelvic infections in women, and involvement of the eye), syphilis, chorea, infectious arthritis (non-gonorrheal), encephalitis, and some forms of asthma. There are other conditions which show promise under this treatment; but the most striking results are seen in gonorrhea and syphilis, since the causative organisms can be destroyed at temperatures compatible with human life⁹.

Equipment for Production of Fever

Various means have been tried for producing artificial fever, including injections of various crystalloid or colloid substances, bacterial products of typhoid and malarial organisms; a number of physical methods, such as hot baths, radiant heat, diathermy, radiotherapy, and in the last few years, air conditioned chambers. The relative advantages and disadvantages of various methods have been discussed in a paper¹⁰. The results by the use of air conditioned cabinets have not been fully explored, and it is therefore difficult to determine all the advantages and disadvantages of the value of air conditioning at this time.

In the earlier studies of the Society¹¹, temperatures were elevated more easily using saturated atmospheres. A fever therapy apparatus¹² using these same principles has proved efficient as a means of inducing and maintaining fever in a body with small likelihood of burns because of the comparatively low dry-bulb temperatures. This saturation factor is in great use today where fever is created by induction currents by placing the body in an electrical field. When the optimum body temperature has been reached by electrical induction, the atmosphere of the

⁹Report of the First Year of Fever Therapy Research by the Department of Industrial Hygiene, School of Medicine, University of Pittsburgh, 1938.

¹⁰Fever Therapy by Physical Means, by Frank H. Krusen and E. C. Elkins (*Journal American Medical Association*, 112. 1689-1696, April 29, 1939).

¹¹A.S.H.V.E. RESEARCH REPORT No. 654—Some Physiological Reactions of High Temperatures and Humidities, by W. J. McConnell and F. C. Houghten (A.S.H.V.E. TRANSACTIONS, Vol. 29, 1923, p. 129).

¹²A.S.H.V.E. RESEARCH REPORT No. 1054—Fever Therapy Induced by Conditioned Air, by F. C. Houghten, M. B. Ferderber and Carl Gutberlet (A.S.H.V.E. TRANSACTIONS, Vol. 43, 1937, p. 131). A.S.H.V.E. RESEARCH REPORT No. 1162—Fever Therapy Locally Induced by Conditioned Air, by M. B. Ferderber, F. C. Houghten and Carl Gutberlet (A.S.H.V.E. TRANSACTIONS, Vol. 46, 1940).

enclosure is kept at saturation to prevent heat loss, thus maintaining the patient's temperature at the desired point. Other apparatus¹³ which uses electric heaters, centrifugal fans, and a water container for humidification has been used in the past, but the more recent trend is toward saturation with a lower dry-bulb temperature.

When heat is necessary in treating legs or arms, such media as short or long wave diathermy, infra-red, water baths, etc. have been used extensively. A recent development, a saturated atmosphere heating unit, similar to one previously described¹⁴ has proven satisfactory, because heat may be administered over longer periods which render deep heating possible without fear of burns or shocks¹⁵. Local heating has been somewhat satisfactory in relieving the painful symptoms of peripheral vascular disease.

The final criteria for the use of fever therapy may be changed because of the introduction of certain drugs which appear prominent in the experimental treatment of some diseases for which fever therapy has been efficacious.

COLD THERAPY

In contrast to fever therapy the use of cold as a means of treatment is being investigated. From the available literature¹⁶ the chief virtues of cold therapy (cryotherapy) are the reduction of pain due to extensive cancer and the possibility that the process may be arrested. For a localized lesion, ice water between 36 to 48 F is circulated through tubing at the site of the disease for periods ranging from 4 to 48 hours. A later development was the principle of hibernation during which time the patient is kept in an air conditioned space with an environmental temperature between 50 to 60 F for five days. The body temperature is reduced below the critical level of 95 F to as low as 80 F. Most of the vital processes of life are at very low ebb and this period simulates the hibernation of the wild animals. Although relief of pain is reported it remains to be seen to what extent this form of treatment will be used.

More recently the principles of refrigeration have been applied to limbs which have been traumatized or in which the blood supply has been hopelessly damaged¹⁷. Lowering of the temperature of the extremity may prevent shock and allow the patient to be transported safely to the hospital. When an amputation is to be undertaken, the limb is frozen and is thus anesthetized. This eliminates the necessity of further anesthesia.

HIGH TEMPERATURE HAZARDS

Heat disease is now classified as heat exhaustion, heat cramps, and heat stroke¹⁸. Heat exhaustion is due to circulatory failure; heat cramps to

¹³Artificial Fever Therapy of Syphilis, by W. M. Simpson (*Journal American Medical Association*, 105: 2132, 1935).

¹⁴Loc. Cit. Note 11.

¹⁵Saturated Atmospheres in the Treatment of Injuries, by M. B. Ferderber (*Industrial Medicine*, 8: 256-259, June, 1939).

¹⁶Temperature Factors in Cancer and Embryonal Cell Growth, by L. W. Smith, and Temple Fay (*Journal American Medical Association*, Vol. 113: 653-660, August, 1939).

¹⁷Reduced Temperatures in Surgery, by F. M. Allen (*American Journal of Surgery*, 52:225, 1941).

¹⁸Heat Disease: Clinical and Laboratory Studies, by M. W. Heilman and E. S. Montgomery (*Journal of Industrial Hygiene and Toxicology*, 18: 651-666, November, 1936).

excessive loss of body chlorides and heat stroke to an inadequacy of the heat dissipating mechanism which results in heat retention. If the hyperthermia becomes excessive, the liver and the central nervous system may be seriously damaged and this damage may prove fatal. The hazards of high temperatures are not easily understood. It is difficult to say whether a repeated rise of 1 or 2 deg of body temperature is dangerous or whether short exposures at high temperatures are more harmful than longer exposures at lower temperatures. A new concept is evident in finding an increase in leucocytes (white cells) of the blood in workers subjected to high temperatures. These leucocytes are defensive factors which are increased when infection invades a body. A rise in temperature and leucocyte count indicates body defense in the presence of disease. Since a recent study¹⁹ showed that both temperature and cell count were increased, the question arises whether long exposures to very high temperatures might not cause exhaustion of these defense mechanisms.

ALLERGIC DISORDERS

Although there is some division of opinion over the ultimate cause of allergy, the prevailing belief is that it is due to an inherited or acquired hypersensitiveness to pollen or other foreign proteins in certain individuals who react abnormally to the offending substance. The reaction may be induced by inhalation, eating, or absorption (through the skin) of the allergens. Some of the clinical manifestations are hay fever, asthma, eczema, and contact dermatitis.

Symptoms of Hay Fever and Asthma

The respiratory tract is the site of probably the most usual allergic manifestations, the so-called hay fevers and asthma. In hay fevers, the nose and eyes are red and itchy, and there is considerable discharge. Nasal obstruction is the most common and most distressing symptom. The severity of the symptoms varies widely from day to day depending chiefly on the amount of pollen in the air.

Seasonal asthma comes in attacks. The most popular theory concerning the mechanism of action is that the offending substance irritates the nerve endings in mucous membranes of the respiratory tract, causing spasmodic contraction of the small bronchioles of the lungs, which interferes with breathing, particularly with expiration. Non-seasonal allergic disturbances are sometimes attributed to house or street dusts, fungi, odors, animal dander, irritating gases, and heat or cold, particularly sudden temperature changes. It is often stated in the literature that heat regulation in asthmatic individuals is likely unstable, with a tendency toward the subnormal. Many allergic cases who are apparently well, develop their attacks when cold weather appears, or upon changing from warm to cool outdoor air.

Air Conditioning Apparatus

In recent years considerable effort has been directed toward the elimination of the principal cause of allergy from the air of enclosures by filtration or other air conditioning processes capable of removing pollens,

¹⁹A.S.H.V.E. RESEARCH REPORT No. 1106—Air Conditioning in Industry, by W. L. Fleisher, A. E. Stacey, Jr., F. C. Houghten and M. B. Ferderber (A.S.H.V.E. TRANSACTIONS, Vol. 45, 1939, p. 59).

in the hope of providing relief to individuals who fail to respond to medical treatment (desensitization or immunization).

Paper or cloth filters, mounted in inexpensive window or floor units, prove quite satisfactory, but since dust and smoke frequently cause asthmatic attacks, it is necessary that an air filter, to be of full value in the treatment of asthma, must remove all dusts and pollens regardless of size or amount. An electrostatic cleaner has proved extremely efficient in removing particles of 15 to 20 microns and smaller, besides dusts and smoke²⁰.

Although the chief remedial factor in the treatment by conditioned air is the filtration of pollen, a certain amount of cooling and dehumidification appears to be desirable. A comfortable temperature between 70 and 75 F and a relative humidity well below 50 per cent proved satisfactory²¹. Direct drafts, overcooling or overheating are apt to initiate or aggravate the symptoms.

Limitations of Air Conditioning Methods

The results obtained with air filtration or other air conditioning processes in the control of allergic conditions are fairly comparable to those obtained by desensitization treatment so long as the patients remain in the pollen free atmosphere. But while specific desensitization is preventive and in a few instances curative, for all practical purposes filtration gives only temporary relief. With rare exceptions, the symptoms recur on exposure to pollen laden air. Moreover the usefulness of air conditioning methods is limited because all cases are not caused by air-borne substances. Cases of bacterial asthma do not respond at all to the treatment with filtered air.

Despite these limitations air conditioning methods possess definite advantages in the simplicity of treatment, convenience, and under certain conditions almost immediate relief. Pollen cases are usually relieved of most of their symptoms within 1 to 3 hours after exposure to properly filtered air.

A pollen-free atmosphere is especially valuable in cases where desensitization has given little or no relief, and where desensitization is not advisable owing to intercurrent illness. On the whole, conditioning methods are considered to be a valuable adjunct in medical diagnosis and treatment of allergic disorders.

OXYGEN THERAPY

Oxygen therapy is the principal measure employed for preventing and relieving the distressing symptoms of anoxemia, which is a deficiency in the oxygen content of the blood. Some of the more important conditions in which oxygen treatment is believed to be beneficial are pneumonias, anemia, heart affections, post-operative pulmonary disturbances, certain mental disturbances, asphyxia, asthma and atelectasis in new-born infants.

The necessity of air conditioning in oxygen therapy arises from the fact

²⁰Air Cleaning as an Aid in the Treatment of Hay Fever and Bronchial Asthma, by Leo H. Crip and M. A. Green (*Journal of Allergy*, 7: 120, January, 1936).

²¹The Effect of Low Relative Humidity and Constant Temperature on Pollen Asthma, by B. Z. Rappaport, T. Nelson and W. H. Welker (*Journal of Allergy*, 6: 111, 1935).

that oxygen is too expensive a gas to waste in the ventilation of oxygen tents and oxygen chambers. The oxygen rich atmosphere in these enclosures is therefore reconditioned in a closed circuit by removal of excess heat, moisture, and carbon dioxide given off from the occupants being treated.

Oxygen Tents

In oxygen tents the air enriched with oxygen is usually circulated by means of a small motor blower which sends the air over soda lime to remove carbon dioxide and then over ice to remove excess heat and moisture. The concentration of oxygen in the tent is regulated by means of a pressure reducing valve and flow meter. In an inadequately cooled tent, high temperatures and humidities are inevitable, increasing the discomfort of the patient and imposing an added strain on an already overburdened heart. Oxygen therapy under such conditions may do more harm than good. An ice melting rate of approximately 10 lb per hour gives satisfactory results in patients with fever in a medium size oxygen tent.

Oxygen tents are somewhat confining to the patient; the restless type of person is difficult to control, and the delirious, impossible to control. Medical and nursing care is complicated, as the tent must be opened or removed with attendant loss of oxygen. Oxygen concentrations of 50 per cent or more are difficult to maintain, and it is a problem to keep the temperature and humidity low enough in hot weather. The direct advantages are portability and low cost.

Oxygen Chambers

The conventional oxygen chamber is an air-tight sheet metal enclosure of fire-proof construction, large enough to accommodate one or two patients. Trap doors or curtains are provided for the personnel, food and service, to avoid loss of oxygen. Glass windows in the ceiling and walls admit light from outside the chamber.

The air conditioning system may be of the gravity type, or of the fan type using mechanical refrigeration or air drying agents. The gravity system includes a bank of cooling coils controlled thermostatically, which dehumidify and cool the air. The cool air falls over trays of soda lime at the bottom of the coils, to remove the carbon dioxide given off by the occupants. A heater at the base of the opposite wall warms the air to the desired temperature. Ordinary industrial oxygen is introduced from storage tanks outside the chamber and the concentration is regulated according to the prescription of the physician. The only change of air in the chamber is that taking place by air leakage through the trap doors.

The chief objections to the gravity circulation system are stratification of cold air near the floor and accumulation of odors, which may require the use of activated charcoal, or an excess of oxygen for dilution of the air in the chamber.

The fan circulation systems include compact extended surface coolers, heaters, and sometimes air-drying beds installed outside the chamber for the removal of moisture.

The temperature and humidity requirement in oxygen therapy depend primarily upon the physical condition of the patient, and secondarily

upon the type of disease. In pneumonias²² prescribed conditions should be an effective temperature of 66 to 68 deg, humidity of 50 per cent, air movement of not less than 50 linear feet per minute, oxygen concentration of 50 per cent, and carbon dioxide of less than 1 per cent.

Oxygen chambers are more comfortable than oxygen tents. The patients receive unhampered medical and nursing care, and the oxygen concentration, the temperature and humidity can be adequately controlled at any desired level. The chief disadvantages are high initial and operating costs in comparison with oxygen tents, the nasal catheter or face mask method of oxygen administration. The nasal catheter method is the simplest and most inexpensive of all but it may cause considerable discomfort to the patient and it is not satisfactory for continuous administration for restless or delirious patients. Moreover, oxygen concentrations greater than 40 per cent in the inspired air are difficult to maintain, although concentrations as high as 48 per cent have been obtained. The face mask is a convenient portable method and permits the administration of oxygen concentrations up to 95-100 per cent in the inspired air. It is economical and convenient and helium-oxygen mixtures may be easily administered.

GENERAL HOSPITAL AIR CONDITIONING

Complete conditioning of a large hospital involves a capital investment and running expense which may not be justified. In clean and quiet districts, the requirements of almost all general and private wards during the cool season of the year can be satisfactorily fulfilled by the use of usual heating in conjunction with window air supply and gravity or mechanical exhaust. Insulation against heat and sound is much more important than humidification in winter; it will also help in keeping the building cool in warm weather. Excessive outside noise and dust may require the use of silencers and air filters in the window openings.

Cooling and dehumidification in warm weather are important. In new hospitals particularly, the desirability of cooling certain sections of the building should be given serious consideration. Financial reasons may preclude the cooling of the entire building, but the needs of the average hospital can be met by the use of built-in room coolers and a few portable units which can be wheeled from ward to ward when needed.

In the North and certain sections of the Pacific Coast, cooling is needed but a few days during summer, while in the South, it can be used to advantage from May to October, and in tropical climates almost continuously throughout the year.

Aside from comfort and recuperative power of the patients, cooling is of great assistance in the treatment of fevers in the new-born and in post-operative cases, in enteric disorders, fevers, heat stroke, heart failure, and in a variety of other ailments which often accompany summer heat waves.

Considerable research is in progress on the influence of air conditioning upon a wide variety of diseases such as pneumonia, upper respiratory diseases, tuberculosis, arthritis, nervous instability, hyper-thyroidism, essential hypertension, skin diseases, and vascular disorders.

²²The Management of Pneumonias, by J. G. M. Bullowa, 1937, p. 260.

TRANSPORTATION AIR CONDITIONING

Railway Passenger Car Ventilation, Method of Air Distribution, Air Cleaning, Winter and Summer Air Conditioning, Humidity and Temperature Control, Summer Air Conditioning for Buses and Automobiles

THE principles of air conditioning used in connection with stationary applications such as stores, restaurants, hospitals, theaters, and homes are in general applicable to such mobile applications as railway passenger cars, passenger buses, automobiles, and ships. However, the equipment used for these mobile applications, with the possible exception of those on board ship, differs from that used for stationary purposes in that it must meet additional requirements. Especially important are the features of compactness with the retention of ready accessibility for quick inspection and servicing, and low weight. Freedom from vibration which could be transmitted to the supporting vehicle and thus to the passengers is essential.

RAILWAY PASSENGER CAR VENTILATION

In non air-conditioned cars, ventilation is accomplished by exhaust fans, roof ventilators, and open doors and windows. This practice provides an ample supply of outside air but does not prevent the entrance of smoke, cinders, and dirt.

An average passenger car contains approximately 5000 cu ft of air and may seat as many as 80 passengers. The occupants are continually liberating heat, carbon dioxide, moisture, odors, and some organic matter from their breath, skin and clothing. The heat and moisture can be removed by cooling and dehumidification, but the other constituents can be successfully handled only by proper ventilation and air cleansing. In the average car from 2000 to 2500 cfm should be circulated by the air conditioning unit. Some of this air may be recirculated, but a portion of it should always be brought in from the outside. The amount of outside air required depends upon the type of car, number of passengers, air temperature, humidity, odors, and whether or not occupants are smoking, and will vary from 15 to 90 per cent of the total air circulated.

Careful attention must be exercised in specifying the rate of outside air taken in so as to fit the type of service adequately and yet not to supply more ventilation than is necessary. Conditioning this outside air is a major factor in determining the size of both summer and winter conditioning equipment. With present average ventilation requirements, about 30 per cent of the cooling equipment and sometimes as high as 50

per cent of the heating equipment is necessary to handle only the outside air load.

For normal conditions, 10 cfm of outside air per passenger is sufficient. When smoking is permitted, at least 15 cfm should be admitted. In some of the dining cars and deluxe sleeping cars, outside air rates as high as 20 and 30 cfm per occupant are used.

Method of Air Distribution

The fact that the amount of space devoted to railway passengers may be as low as 60 cu ft per person (ranging as high as 190 cu ft per person), coupled with the high air flow rates made necessary by severe ventilation and sun loads, makes the problems of air distribution and air delivery in railway cars critical ones.

Various methods may be used to distribute the air delivered to the interior of the car by the circulating fan or blower. The methods commonly used are:

1. A duct lengthwise along the center of the car.
2. One or two side ducts built on the outside of monitor-roofed cars, or on the inside of turtle-backed or arched-roofed cars.
3. Free discharge at the end bulkheads, or by free discharge from a unit placed overhead in the center of the car, discharging toward the ends. This bulkhead delivery system, while inexpensive, is apt to cause complaints due to drafts, and, accordingly, is not being favored.

Delivery grilles and plaques are used, and are often designed to give considerable entrainment and mixing to avoid cool drafts.

Smoking rooms present a special problem. The cloud of smoke that usually hangs near the ceiling can be broken up by having the incoming air directed along the ceiling in all directions at a velocity somewhat higher than that used for the rest of the car. The air should be exhausted from the room by a fan or through a grille to the washroom or lavatory, and then outside by a fan in a ventilator.

For compartments an adjustable supply duct outlet grille of suitable size and design should be provided and provisions made in the door or partition for the removal of the air to be recirculated.

Lower berths in sleeping cars and office cars should be provided with an adjustable air outlet which will discharge the amount of air desired at low velocity in any direction so that the occupant can regulate the ventilation to meet his own requirements.

In cars containing but one or two rooms or compartments, satisfactory results may be obtained by discharging the air directly from the conditioning unit into the upper part of the car. Care must be taken to have a proper discharge velocity. If the velocity is too low, the air will drop before reaching the end of the car and if too high it will discharge against the end bulkhead and be reflected back. Care must be exercised to secure proper circulation, otherwise objectionable drafts will be experienced.

The recirculating air grilles are usually of the straight flow type, and should be located so that objectionable drafts will not be created by the return air. The outside air intakes, located in the car vestibule, on the side of the car, or on the roof of the car, depending upon the location of the cooling coils, should be of ample size to permit the entrance of suf-

ficient outside air. On many of the recently air-conditioned cars, there are no dampers or shutters at the outside air intakes, the percentage of outside air being controlled by blocking the flow through the recirculating grille.

Air Cleaning

All of the air circulated by the blower is filtered before passing over the cooling coils. In some cars the outside and recirculated air are filtered separately before mixing, while on others the air from the two sources is mixed before passing through a common filter. Filters in use are made of metal, wool, cloth, spun glass, hemp, paper, hair, and wire screen. Most filters have a viscous coating of oil for greater cleaning efficiency. Some types may be cleaned, retreated, and returned to service while other types are discarded when dirty.

RAILWAY PASSENGER CAR WINTER AIR CONDITIONING

The majority of cars in service use steam from the locomotive or from a head-end, oil-fired boiler as a source of energy for winter heating. In some instances electrical energy from either a head-end generating set or motive power supply is utilized for resistance heating. In still other cases electrical energy and waste heat from individual car engine-generator sets is employed. The peak heating loads which depend largely upon the amount of insulation used in the car, the type of windows (whether single or double glazed), and the ventilation rate, may vary from 150,000 to 250,000 Btu per hour.

In order to temper the cold outside air, about 30 to 50 per cent of the total heat energy required is distributed by means of finned coils or resistance heaters located in the outside air duct. The remainder is usually transmitted to the car air by finned tubing located along the sides of the car near the floor, thus preventing cold convection currents falling from the car windows from reaching the feet of the passengers.

RAILWAY PASSENGER CAR SUMMER AIR CONDITIONING

Three general types of cooling or refrigerating equipment are being used in the 11,700 railway cars which are now air conditioned in the United States. Of these 3,900 are ice-activated, 1,900 use steam jet systems, and 5,900 employ mechanical compression schemes. These systems which functionally are identical with those used for stationary applications (see Chapter 25) are modified in design to meet the requirements of mobile service. Contrasted with stationary applications of summer conditioning equipment, the use of water as a final means of heat disposal from condensers cannot be resorted to because water in such quantities cannot be transported economically. Accordingly, air cooled or evaporative condensers are always used, with the result that mobile cooling equipments operate at higher temperature, pressure, and power requirement levels than stationary equipment.

The maximum cooling and dehumidifying load which depends largely upon the amount of insulation, the type of windows, the ventilation rate, the sun intensity, and the number of passengers may vary from 60,000 to 96,000 Btu per hour.

An average ice-activated system for such capacities uses about 500 lb of ice and 1.2 kw per hour. The increase in car weight due to such a system is approximately 8500 lb.

The same service from a steam jet system is obtained with the expenditure of 230 lb of steam and 3.3 kw per hour, with an added weight per car of 11,000 lb.

The mechanical compression systems, all of which use dichlorodifluoromethane as a refrigerant, may be classified by several types depending on the method of driving the compressor. The source of power for driving the compressor (approximately 10 hp) is complicated by the necessity of obtaining this power at all times whether the car is in motion or standing still on the right-of-way or in a terminal where auxiliary power plug-ins are available. In those cases where compressors are driven from car axles, additional refinements in the drive are necessary in order that a nearly constant cooling capacity may be obtained from a variable speed power source. Numerous combinations of electrical generating schemes for generating sufficient electrical energy from the car axle for lighting, ventilation, and summer air conditioning are in use, and their operation is closely interlocked with compressor demands, need for pre-cooling, battery charging, etc. It is difficult therefore to state the additional weight imposed on a car because of such a compression air conditioning system, but it is probably in the vicinity of 6000 lb. These systems, depending mostly upon the locomotive for supplying power for operation, impose a load which may amount to 10 per cent of the capacity of the locomotive.

Several schemes for relieving the locomotive of this compression load are used. Some of the articulated trains, which run as unit equipment—the same cars always in the same train—employ a head-end, engine-generator combination for supplying power to compressor motors. In other cases engine-alternators on individual cars are used to supply alternating current power to compressor motors, as well as to supply all power for car lighting and auxiliaries. Engine-compressor combinations on individual cars provide attractive low weight equipment where continuous engine operation is permissible under all circumstances. Diesel engines and propane engines are used for these purposes, and such engine-driven units have the additional advantage of being able to use waste engine heat either for modulating refrigeration with a reheat cycle or for car heating purposes.

RAILWAY PASSENGER CAR HUMIDITY AND TEMPERATURE CONTROL

The temperature to be maintained in a car depends upon the outside temperature and the humidity desired inside the car. With a low humidity it is necessary to maintain a higher temperature to establish a desirable comfort condition. Little humidity control has been attempted on cars up to the present time. A certain degree of automatic humidity control is secured with cooling, but the relative humidity obtained depends largely upon the temperature of the evaporator, which should be below the dew-point temperature of the air. With certain outside atmospheric conditions it may not be possible to operate the conventional equipment with a sufficiently low evaporator temperature to reduce the humidity

without dropping the temperature too low. One method has been developed whereby the evaporator temperature is carried below the dew-point a sufficient amount to insure dehumidification and then the cold air is heated to the proper temperature by passing it over coils through which part of the high temperature liquid from the condenser is by-passed. Such a system is costly and has not been generally applied. The reheat cycle obtainable from waste engine heat may be used to good advantage in reducing the humidity without reducing the dry-bulb temperature.

During the heating season humidification is desirable from a comfort standpoint, but unless properly controlled, condensation will appear on the windows. A steam or water spray controlled by a humidistat will provide the necessary moisture for humidification. There are several cars with this feature now in use.

Temperature control for the most part obtained by rugged thermostats and relays capable of withstanding vibrations attendant with mobile service is usual equipment.

Manual zone control for varying outdoor conditions, as well as controls which regulate the car temperature automatically in accordance with outdoor conditions, are employed.

Simplified controls from the standpoint of operation by train crews and especially from the servicing viewpoint are very desirable. The control of summer temperatures is accomplished mainly by cycling the complete cooling system; however, modulation is being effected by using multiple evaporators in which a fixed portion may be cut out of the system. In the engine-driven equipments, modulation is obtained by changing engine speed.

For further information on controls, see Chapter 34.

PASSENGER BUS SUMMER AIR CONDITIONING AND VENTILATION

The highways in the United States are now traveled by about 1000 summer air conditioned passenger buses. Many of the facts stressed in connection with the design and installation of summer conditioning equipment in railway cars are even more important in these newer vehicles. Weight and space limitations are more stringent, and the problem of circulating from 900 to 1200 cfm of air in coaches carrying from 25 to 40 passengers with about 35 cu ft of space per passenger without drafts is no easy one.

Some bulkhead delivery systems have been used, and while the overhead package racks have served to break up drafts to some extent, these installations are not gaining in popularity. Longitudinal ducts in the corners above the package racks are sometimes used to carry conditioned air to a series of outlet louvers along the top of the windows. Other designs provide for false spaces below the package racks which serve as ducts to distribute air to either entrainment grilles in the bottom of the racks or distributing slots at the edges of the package racks. Some coaches employ a false ceiling to provide a duct, with delivery taking place from numerous perforations in the ceiling.

Return air grilles and filters are usually located near the rear ceiling where the evaporator is placed. Outside air intakes and filters are located

preferably near the front of the vehicle so as not to contaminate this supply with exhaust fumes and road dust. Of the 30 cfm circulated per person, about 8 to 10 cfm are outside air and the remainder is recirculated. Power for the motor driving the centrifugal fans is obtained from the bus battery.

More recently a coach design has been brought out which provides for a number of return air outlets below the seats; these permit return air to enter a longitudinal duct below the floor. The filters and evaporator are located in this duct near the front of the vehicle. In this instance a central heating coil utilizing waste heat from the coach engine is also located in this duct. Conditioned air is delivered through a pair of vertical ducts to a package rack distribution scheme.

Summer conditioning systems for these vehicles range in cooling capacity from 36,000 to 48,000 Btu per hour. Mechanical compression systems using dichlorodifluoromethane are used, and are powered by water cooled, gasoline engines of approximately 14 hp.

Complete systems add from 800 to 1300 lb to the weight of a coach. Sometimes an auxiliary generator driven by the air conditioning engine is used which serves to help charge the bus battery and thus offsets the power drain imposed by the ventilating blower. Belted reciprocating compressors and direct driven V-type and rotary compressors are used, with engine speeds up to about 1800 rpm. Air cooled condensers for this service require about 5000 cfm of outdoor air, and this is provided by either centrifugal or propellor type fans belted or direct driven by the air conditioning engine. Preventing noise and vibration from affecting passengers is of vital importance. Installations must be made so that quick daily servicing of the engine is possible. In all cases fuel is obtained from the main bus tanks, and in some cases the main engine jacket water cooling system is used to cool the air conditioning engine.

In the more deluxe equipment after the driver has started the air conditioning engine by means of its own cranking motor, the engine speed is modulated automatically as the refrigeration demand is partially met, and if this demand is then fully met, the engine is stopped thermostatically. Restarting when the cooling thermostat is no longer satisfied is accomplished either automatically or manually. The various protective and automatic devices on the refrigerant and engine systems make some of the bus air conditioning control systems quite complicated.

AUTOMOBILE SUMMER AIR CONDITIONING

Recently summer air conditioning has been applied to automobiles. The average present day automobile with little insulation, large, single glazed window areas, and high infiltration and exfiltration losses requires about 15,000 Btu per hour of cooling capacity. One system utilizes a reciprocating compressor belted from the main engine fan shaft thus operating at varying speeds up to 3000 rpm. The resulting refrigeration capacity varies from about 6000 Btu per hour at idling speed to 24,000 Btu per hour at maximum car speed.

A dry air condenser is placed in front of the engine radiator, and the liquid and suction refrigerant lines run back under the car floor to the

evaporator which is located in back of the rear seat. Conditioned air is delivered into the car just above the shelf near the back of the rear seat. A return grille is provided under the rear seat, and the recirculated air is filtered. Outdoor air is provided by infiltration. Power for the air circulating blowers is obtained from the car storage battery. Equipment of this nature increases the car weight approximately 200 lb.

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Chapter 39

INDUSTRIAL AIR CONDITIONING

Atmospheric Conditions Required, General Requirements, Classification of Problems, Control of Regain, Moisture Content and Regain, Conditioning and Drying, Control of Rate of Chemical Reaction, Control of Rate of Biochemical Reactions, Control Rate of Crystallization, Elimination of Static Electricity

A COMPLETE knowledge of the problems involved is necessary before a satisfactory solution can be made of industrial air conditioning problems. Individual processes and machines are changing rapidly and air conditions must be constantly revised to meet the new conditions.

ATMOSPHERIC CONDITIONS REQUIRED

The most desirable relative humidity for processing depends upon the product and the nature of the process. As far as the behavior of the material and its desired final condition are concerned, each material and process presents a different problem. The desirable relative humidity may range from a low of 5 per cent, as in certain industrial applications, such as insulation winding processes, up to a condition approaching saturation, as in processes relating to textiles, tobacco and baking industries.

Similarly, the most favorable temperature will vary according to the specific material and particular process. Frequently a compromise between the known optimum condition for processing and that required for reasonable worker comfort is desirable. This is particularly true where unconfined processes are required in departments where people are working and their health, comfort and productive efficiency must be considered.

It is generally recognized that relative humidities of 50 per cent or less are on the dry side. Such conditions are conducive to low regains in hygroscopic materials, drying out, increased brittleness of fibrous materials, prevalence of increased static electricity and tendencies toward increased dust liberation from the product. Relative humidities higher than 50 per cent are considered to be on the damp side. These conditions are conducive to high regain, promote softness and pliability in materials, decrease static electricity and tendencies toward reduced generation of product dust which represents a loss in weight of the material in process.

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TABLE 1. TEMPERATURES AND HUMIDITIES APPLICABLE TO INDUSTRIAL AIR CONDITIONING

INDUSTRY	PROCESS	TEMPERATURE DEGREES FAHRENHEIT	RELATIVE HUMIDITY PER CENT
AUTOMOBILE.....	Assembly line.....	65 to 80	40 to 55
	Precision parts—honing—machining.....	75 to 80	40 to 55
BAKING.....	Cake icing.....	70	50
	Cake mixing.....	75	65
	Dough fermentation room.....	80	76 to 80
	Loaf cooling.....	70	60 to 70
	Make-up room.....	75 to 80	55 to 70
	Mixing room.....	75 to 80	55 to 70
	Paraffin paper wrapping.....	80	55
	Proof boxes.....	80 to 90	80 to 95
	Storage of flour.....	70 to 80	60
	Storage of yeast.....	28 to 40	60 to 75
BIOLOGICAL PRODUCTS.....	Vaccines.....	below 32	
	Antitoxins.....	38 to 42	
	Blood bank.....	38 to 42	60 to 65
BREWING.....	Fermentation in vat room.....	44 to 50	50
	Storage of grains.....	60	30 to 45
CERAMIC.....	Drying of auger machine brick.....	180 to 200	
	Drying of refractory shapes.....	110 to 150	50 to 60
	Molding room.....	80	60
	Storage of clay.....	60 to 80	35 to 65
CHEMICAL.....	General storage.....	60 to 80	35 to 50
CONFECTIONERY..	Chewing gum rolling.....	75	50
	Chewing gum wrapping.....	70	45
	Chocolate covering.....	62 to 65	50 to 55
	Hard candy making.....	70 to 80	30 to 50
	Packing.....	65	50
	Starch room.....	75 to 85	50
	Storage.....	60 to 68	50 to 65
DISTILLERY.....	General manufacture.....	60 to 75	45 to 65
	Storage of grains.....	60	30 to 45
DRUG	Deliquescent powder.....	75	35
	Effervescent granulations.....	80	40
	Liver extracts (powdered).....	70	20 to 30
	Storage of powders and tablets.....	70 to 80	30 to 35
	Tablet compressing.....	70 to 80	40
	Packaging.....	80	40
ELECTRICAL.....	Insulation winding.....	104	5
	Manufacture of cotton covered wire.....	60 to 80	60 to 70
	Manufacture of electrical windings.....	60 to 80	35 to 50
	Storage of electrical goods.....	60 to 80	35 to 50
FOOD	Butter making.....	60	60
	Dairy chill room.....	40	60
	Preparation of cereals.....	60 to 70	38
	Preparation of macaroni.....	70 to 80	38
	Ripening of meats.....	40	80
	Slicing of bacon.....	60	45
	Storage of apples.....	31 to 34	75 to 85
	Storage of citrus fruit.....	32	80
	Storage of eggs in shell.....	30	80
	Storage of meats.....	0 to 10	50
	Storage of sugar.....	80	35
FUR.....	Drying of furs.....	110	
	Storage of furs.....	28 to 40	25 to 40
INCUBATORS.....	Chicken.....	99 to 102	55 to 75

CHAPTER 39. INDUSTRIAL AIR CONDITIONING

TABLE 1. TEMPERATURES AND HUMIDITIES APPLICABLE TO INDUSTRIAL AIR CONDITIONING—(Concluded)

INDUSTRY	PROCESS	TEMPERATURE DEGREES FAHRENHEIT	RELATIVE HUMIDITY PER CENT
LABORATORY.....	General analytical and physical.....	60 to 70	60 to 70
	Storage of materials.....	60 to 70	35 to 50
LEATHER.....	Drying of hides.....	90	
	Mulling.....	95 to 100	95
LIBRARY.....	Book storage (see discussion in this chapter)	65 to 70	38 to 50
LINOLEUM.....	Printing.....	80	40
MATCHES.....	Manufacturing.....	72 to 74	50
	Storage of matches.....	60	
MUNITIONS.....	Fuse loading.....	70	55
PAINT.....	Air drying lacquers.....	70 to 90	25 to 50
	Baking lacquers.....	180 to 300	
	Air drying of oil paints.....	60 to 90	25 to 50
PAPER.....	Binding, cutting, drying, folding, gluing..	60 to 80	40 to 60
	Storage of paper.....	75 to 80	40 to 60
	Testing Laboratory.....	60 to 80	55 to 65
PHOTOGRAPHIC....	Development of film.....	70 to 75	60
	Drying.....	75 to 80	50
	Printing.....	70	70
	Cutting.....	72	65
PRINTING.....	Binding.....	70	45
	Folding.....	77	65
	Press room (general).....	75	60 to 78
	Press room (lithographic).....	75 to 80	50 to 60
	Storage of rollers.....	70 to 90	50 to 55
RUBBER.....	Manufacturing.....	90	
	Dipping of surgical rubber articles.....	75 to 80	25 to 30
	Standard laboratory tests.....	80 to 84	42 to 48
	Cementing.....	80	25 to 30
SOAP.....	Drying.....	110	70
TEXTILE.....	Cotton— carding.....	75 to 80	50 to 55
	combing.....	75 to 80	60 to 65
	roving.....	75 to 80	50 to 60
	spinning.....	60 to 80	50 to 70
	weaving.....	68 to 75	85
	Rayon— spinning.....	70	85
	throwing.....	70	60
	weaving.....	75 to 88	60 to 75
	Silk— dressing.....	75 to 80	60 to 65
	spinning.....	75 to 80	65 to 70
	throwing.....	75 to 80	65 to 70
	weaving.....	75 to 80	60 to 70
	Wool— carding.....	75 to 80	65 to 70
	spinning.....	75 to 80	55 to 60
	weaving.....	75 to 80	50 to 55
	Testing Laboratory.....	70	65
TOBACCO.....	Cigar and cigarette making.....	70 to 75	55 to 75
	Softening.....	90	85
	Stemming or stripping.....	75 to 85	70

In many processes, the optimum desired air conditions are a variable according to the stage and progress of the processing cycle, from the raw material to the finished product. Some materials, such as cotton textiles, begin with a low relative humidity in the carding and picking rooms, and after passing through the various intermediate steps with a gradual increase of relative humidity, the product is subjected to relative humidities of from 75 to 85 per cent in the final stage of weaving. Other processes are encountered that require the reverse of this procedure, starting with a high relative humidity and finishing with a low relative humidity, as is the case with gelatine capsule making, glue and gelatinous materials.

In some cases the temperatures listed in the Table 1 have no direct influence upon the product itself, except as it affects the efficiency of the employees and thus the quality of workmanship, uniformity and the cost of production. In this category may be included the automobile assembly line. The time necessary to assemble the many parts into a complete unit is a factor recognized and associated with the worker's comfort, and the avoidance of fatigue with subsequent loss of efficiency.

Air conditioning contributes an important role during the processing, machining and honing of precision metal parts, instruments, tools, engines, guns, etc., which demand micrometric accuracy of dimensions, and which are affected by small temperature variations. Hence, some uniform condition is usually selected, both as to temperature and humidity to serve the demands of the worker's comfort and the exacting requirements of the process.

The temperatures and relative humidities listed in Table 1 should be analyzed with consideration in relation to the qualified requirements of the process. Conditions generally acceptable for *industrial processing* and for *general storage* are listed in these tables. While it is true that many storage requirements demand the control of some fixed air temperature and relative humidity condition, to hold and preserve the contents, it is not generally referred to as *processing*.

Logically many phases of drying may be included in the category of air conditioning for industrial processing, especially where temperature and humidity, by direct influence to product, bring about some definite change in physical characteristics as well as in weight. (See also Chapter 41.) As an illustration, refer to the conditions that are required to control the rate of crystallization in coating pans in which sugar syrup is applied to various forms of pills, nuts, gum, etc., in consecutive liquid doses, until a crystallized coating or jacket is built up to the required size and thickness. Here, the primary problem is one of drying which requires the supply of air at some fixed volume and velocity along with regulated control of both dry- and wet-bulb temperatures. The wet-bulb depression determines the rate of moisture pick-up or drying by the air and may be termed the *drying head*. Of equal importance is the uniformity at which the wet-bulb is maintained. If this is allowed to vary, poor results will follow due to checking and cracking of the unfinished coating. This is obvious when it is realized that continuous evaporation of moisture is taking place during the process and also that the temperature of the material corresponds to the air wet-bulb temperature and will vary accordingly. With undue expansion and contraction, with every tem-

perature change, the thin crystallized coatings which are not elastic will check and crack before the process is completed.

GENERAL REQUIREMENTS

Air conditioning apparatus for industrial purposes must be capable of absorbing heat from various sources such as machinery power, electric lights, people, sunlight and chemical reactions; of warming or cooling to any desired temperature; and of providing ample air supply. Refrigeration may or may not be required, depending upon natural conditions, the required relative humidity and the maximum permissible temperature. Washing, purifying and treating the air may be desirable. Good distribution is essential for the control of air motion and for the prevention of uneven conditions. Accurate, sensitive and reliable automatic control of humidity or temperature is vital in most cases.

Outside weather conditions and the ventilation required for workers are of secondary importance in relation to the total work to be done by the air conditioning system. In extreme cases of high concentration of industrial heat from machinery and ovens the error of entirely omitting the heat gain through the building structure would not be serious. At the other extreme, where low temperatures must be produced with refrigeration and where comparatively little power is required by the machinery, the heat gain through the building structure will become the major factor in determining the size of equipment and in this case the ventilation requirement assumes importance.

Buildings which are to be air conditioned should therefore be designed with careful consideration of overall cost and efficiency. Condensation resulting from high humidities must be prevented by suitable materials and construction, or else collected and drained to prevent loss of product or quick deterioration of the structure. Air leakage or filtration may add greatly to operating costs or make the maintenance of low humidities (relative or absolute) wholly impossible. Low temperatures require good insulation.

It is apparent that the subject of air conditioning for industrial processes is extensive and greatly involved, and that a detailed treatment is therefore beyond the scope of this chapter.

CLASSIFICATION OF PROBLEMS

Any industrial air conditioning problem may be listed under one or more of the following five classifications: 1. Control of regain, 2. Control of rate of chemical reactions, 3. Control of rate of biochemical reactions, 4. Control of rate of crystallization, and 5. Elimination of static electricity.

Control of Regain

In the manufacture or processing of hygroscopic materials such as textiles, paper, wood, leather, tobacco and foodstuffs, the temperature and relative humidity of the air have a marked influence upon the rate of production and upon the weight, strength, appearance and general quality of the product. This influence is due to the fact that the moisture

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TABLE 2. REGAIN OF HYGROSCOPIC MATERIALS

Moisture Content Expressed in Per Cent of Dry Weight of the Substance at Various Relative Humidities—Temperature, 75 F

CLASSIFICATION	MATERIAL	DESCRIPTION	RELATIVE HUMIDITY—PER CENT										AUTHORITY
			10	20	30	40	50	60	70	80	90		
Natural Textile Fibers	Cotton	Sea island—roving	2.5	3.7	4.6	5.5	6.6	7.9	9.5	11.5	14.1	Hartshorne	
	Cotton	American—cloth	2.6	3.7	4.4	5.2	5.9	6.8	8.1	10.0	14.3	Schloesing	
	Cotton	Absorbent	4.8	9.0	12.5	15.7	18.5	20.8	22.8	24.3	25.8	Fuwa	
	Wool	Australian merino—skein	4.7	7.0	8.9	10.8	12.8	14.9	17.2	19.9	23.4	Hartshorne	
	Silk	Raw chevennes—skein	3.2	5.5	6.9	8.0	8.9	10.2	11.9	14.3	18.8	Schloesing	
	Linen	Table cloth	1.9	2.9	3.6	4.3	5.1	6.1	7.0	8.4	10.2	Atkinson	
	Linen	Dry spun—yarn	3.6	5.4	6.5	7.3	8.1	8.9	9.8	11.2	13.8	Sommer	
	Jute	Average of several grades	3.1	5.2	6.9	8.5	10.2	12.2	14.4	17.1	20.2	Storch	
	Hemp	Manila and sisal—rope	2.7	4.7	6.0	7.2	8.5	9.9	11.6	13.6	15.7	Fuwa	
Rayons	Viscose Nitrocellulose Cupramonium	Average skein	4.0	5.7	6.8	7.9	9.2	10.8	12.4	14.2	16.0	Robertson	
	Cellulose Acetate	Fibre	0.8	1.1	1.4	1.9	2.4	3.0	3.6	4.3	5.3	Robertson	
Paper	M. F. Newsprint	Wood pulp—24% ash	2.1	3.2	4.0	4.7	5.3	6.1	7.2	8.7	10.6	U. S. B. of S.	
	H. M. F. Writing	Wood pulp—3% ash	3.0	4.2	5.2	6.2	7.2	8.3	9.9	11.9	14.2	U. S. B. of S.	
	White Bond	Rag—1% ash	2.4	3.7	4.7	5.5	6.5	7.5	8.8	10.8	13.2	U. S. B. of S.	
	Com. Ledger	75% rag—1% ash	3.2	4.2	5.0	5.6	6.2	6.9	8.1	10.3	13.9	U. S. B. of S.	
	Kraft Wrapping	Coniferous	3.2	4.6	5.7	6.6	7.6	8.9	10.5	12.6	14.9	U. S. B. of S.	
Misc. Organic Materials	Leather	Sole oak—tanned	5.0	8.5	11.2	13.6	16.0	18.3	20.6	24.0	29.2	Phelps	
	Catgut	Racquet strings	4.6	7.2	8.6	10.2	12.0	14.3	17.3	19.8	21.7	Fuwa	
	Glue	Hide	3.4	4.8	5.8	6.6	7.6	9.0	10.7	11.8	12.5	Fuwa	
	Rubber	Solid tire	0.11	0.21	0.32	0.44	0.54	0.66	0.76	0.88	0.99	Fuwa	
	Wood	Timber (average)	3.0	4.4	5.9	7.6	9.3	11.3	14.0	17.5	22.0	Forest P. Lab.	
	Soap	White	1.9	3.8	5.7	7.6	10.0	12.9	16.1	19.8	23.8	Fuwa	
	Tobacco	Cigarette	5.4	8.6	11.0	13.3	16.0	19.5	25.0	33.5	50.0	Ford	
	White Bread		0.5	1.7	3.1	4.5	6.2	8.5	11.1	14.5	19.0	Atkinson	
Food-stuffs	Crackers		2.1	2.8	3.3	3.9	5.0	6.5	8.3	10.9	14.9	Atkinson	
	Macaroni		5.1	7.4	8.8	10.2	11.7	13.7	16.2	19.0	22.1	Atkinson	
	Flour		2.6	4.1	5.3	6.5	8.0	9.9	12.4	15.4	19.1	Bailey	
	Starch		2.2	3.8	5.2	6.4	7.4	8.3	9.2	10.6	12.7	Atkinson	
	Gelatin		0.7	1.6	2.8	3.8	4.9	6.1	7.6	9.3	11.4	Atkinson	
	Asbestos Fiber	Finely divided	0.16	0.24	0.26	0.32	0.41	0.51	0.62	0.73	0.84	Fuwa	
Misc Inorganic Materials	Silica Gel		5.7	9.8	12.7	15.2	17.2	18.8	20.2	21.5	22.6	Fuwa	
	Domestic Coke		0.20	0.40	0.61	0.81	1.03	1.24	1.46	1.67	1.89	Selvig	
	Activated Charcoal	Steam activated	7.1	14.3	22.8	26.2	28.3	29.2	30.0	31.1	32.7	Fuwa	
	Sulphuric Acid	H ₂ SO ₄	33.0	41.0	47.5	52.5	57.0	61.5	67.0	73.5	82.5	Mason	

content of materials having a vegetable or animal origin, and to a lesser extent minerals in certain forms, comes to equilibrium with the moisture of the surrounding air.

In industries where the physical properties of a product affect its value, the percentage of moisture is of special importance. With increase in moisture content, hygroscopic materials ordinarily become softer and more pliable. Standards of regain are firmly fixed in trade with fair penalties for excesses. Deficiencies result in loss of revenue to seller and loss of desirable quality to buyer.

Manufacturing economy therefore requires that the moisture content be maintained at a percentage favorable to rapid and satisfactory manipulation and to a minimum loss of material through breakage. A uniform condition is desirable in order that high speed machinery may be adjusted permanently for the desired production with a minimum loss from delays, wastage of raw material and defective product.

In the processing of hygroscopic materials, it is usually necessary to secure a final moisture content suitable for the goods as shipped. Where the goods are sold by weight, it is proper that they contain a normal or standard moisture content.

Moisture Content and Regain

The terms *moisture content* and *regain* refer to the amount of moisture in hygroscopic materials. *Moisture content* is the more general term and refers either to free moisture (as in a sponge) or to hygroscopic moisture (which varies with atmospheric conditions). It is usually expressed as a percentage of the total weight of material. *Regain* is more specific and refers only to hygroscopic moisture. It is expressed as a percentage of the *bone-dry* weight of material. For example, if a sample of cloth weighing 100.0 grains is dried to a bone-dry weight of 93.0 grains, the loss in weight, or 7.0 grains, represents the weight of moisture originally contained. This expressed as a percentage of the total weight (100.0 grains) gives the moisture content or 7 per cent. The regain, which is expressed as a percentage of the bone-dry weight, is $\frac{7.0}{93.0}$ or 7.5 per cent.

The use of the term *regain* does not imply that the material as a whole has been completely dried out and has re-absorbed moisture. During the processing of certain textiles, for instance, complete drying during manufacturing is avoided as it might appreciably reduce the ability of the material to re-absorb moisture. A basis for calculating the regain of textiles is obtained by drying under standard conditions a sample from the lot and the dry weight thus obtained is used as a basis in the calculations to determine the regain.

The moisture content of an hygroscopic material at any time depends upon the nature of the material and upon the temperature and especially the relative humidity of the air to which it has been exposed. Not only do different materials acquire various percentages of moisture after prolonged exposure to a given atmosphere, but the rate of absorption or drying varies with the nature of the material, its thickness and density.

Table 2 shows the regain or hygroscopic moisture content of several

organic and inorganic materials when in equilibrium at a dry-bulb temperature of 75 F and various relative humidities. The effect of relative humidity on regain of hygroscopic substances is clearly indicated. The effect of temperature is comparatively unimportant. In the case of cotton, for instance, an increase in temperature of 10 F has the same effect on regain as a decrease in relative humidity of one per cent. Changes in temperature do, however, affect the rate of absorption or drying. Sudden changes in temperature cause temporary fluctuations in regain even when the relative humidity remains stationary.

The regain or moisture content affects the physical properties of textiles to a marked degree, changing the strength, pliability and elasticity.

The fact that the regain of textiles will come into equilibrium with the conditions of the surrounding air and vary with its temperature and relative humidity is the fundamental basis for the control of physical qualities during manufacture. During the preparation processes in a cotton mill, the cotton fibers should be in a condition to be easily carded.

These preliminary processes are carried out best in a relative humidity of 50 to 55 per cent. As the cotton fiber comes to the spinning operation, more flexibility is needed and the relative humidity is increased in this department. For many years, 65 per cent relative humidity was considered the optimum. To offset the extra work performed on the fiber as the spindle speed is increased, many cotton mills now carry 70 per cent relative humidity in the spinning rooms.¹ Winding, warping and weaving are all processes calling for great flexibility and a consequent need for higher humidity.

Other textile fibers, due to their different natural characteristics, are processed under relative humidities and temperatures applicable to each.

Rayons, on account of great loss of strength with the higher regains, should be processed in a relative humidity of 55 to 70 per cent. Acetate silk, another chemical fiber, with approximately 50 per cent of the regain of rayon, may be processed between 60 and 65 per cent relative humidity.

All hygroscopic materials when in the state of absorbing moisture from the surrounding air produce a sensible heat rise to the air equivalent to the latent heat released by air to the material. This adiabatic conversion may account for a small percentage of the total heat load of the conditioned space.

Conditioning and Drying

In general, the exposure of materials to desirable conditions for treatment may be coincidental with the manufacture or processing of the materials, or they may be treated separately in special enclosures. This latter treatment may be classified as conditioning or drying. The purpose of conditioning or drying is usually to establish a desired condition of moisture content and to regulate the physical properties of the material.

When the final moisture content is lower than the initial one, the term *drying* is applied. If the final moisture content is to be higher, the process

¹The Present Status of Textile Regain Data, by A. E. Stacey, Jr. (*National Association of Cotton Manufacturers*, 1927).

is termed *conditioning*. In the case of some textile products and tobacco, for example, drying and conditioning may be combined in one process for the dual purpose of removing undesirable moisture and accurately regulating the final moisture content. Either conditioning or drying are frequently made continuous processes in which the material is conveyed through an elongated compartment by suitable means and subjected to controlled atmospheric conditions.

Control of Rate of Chemical Reactions

A typical example of the second general classification, that is the control of the rate of chemical reactions, occurs in the manufacture of rayon. The pulp sheets are conditioned, cut to size, and passed through a mercerizing process. It is essential that during this process close control of both temperature and relative humidity should be maintained. Temperature controls the rate of reaction directly, while the relative humidity maintains a constant rate of evaporation from the surface of the solution and gives a solution of known strength throughout the mercerizing period.

Another well-known example of this class is the *drying* of varnish which is an oxidizing process dependent upon temperature. High relative humidities have a retarding effect on the rate of oxidation at the surface and allow the internal gases to escape freely as the chemical oxidizers *cure* the varnish from within. This produces a surface free from bubbles and a film homogeneous throughout. Desirable temperatures for *drying* varnish vary with the quality. A relative humidity of 65 per cent is beneficial for obtaining the best processing results.

Control of Rate of Biochemical Reactions

In the field of biochemical control, industrial air conditioning has been applied to many different and well-known products. All problems involving fermentation are classed under this heading. As biochemistry is a subdivision of chemistry, subject to the same laws, the rate of reaction may be controlled by temperature. An example of this is the dough room of the modern bakery. Yeast develops best at a temperature of 80 F. A relative humidity of 65 per cent is maintained so as to hold the surface of the dough open to allow the carbon dioxide gases formed by the fermentation to pass through and produce a loaf of bread, when baked, of even, fine texture without large voids.

Another example of a similar process is found in the curing of macaroni. The flour and water mixture is fermented and dried. As it is necessary to have a definite amount of water present to carry on a fermentation process, the moisture must be removed in a relatively short period to stop fermentation and prevent souring and in such a manner as to avoid setting up internal strains in the mixture. Best results are obtained with the correct cycles of both temperature and humidity.

The curing of fruits, such as bananas and lemons, also comes under this classification. Bananas are treated somewhat differently and to accomplish the required results, a cycle of temperatures and relative humidities is used. The starches in the pulp of the fruit must be changed and the skin cured and colored, after which the fruit is cooled to maintain as low

a rate of metabolism as possible. Ideal conditions range between 55 to 57 F and in no case should the temperature go below 49 F, as the starches then become fixed and are indigestible.

The curing of lemons is an entirely different problem. Bananas are cured for a quick market, while lemons are held for a future market. The process, therefore, varies in the temperature used. Temperatures from 54 to 59 F have been found to be best suited for this process. A high relative humidity of 88 to 90 per cent is necessary to hold shrinkage to a minimum and, at the same time, develop the rind so it will be sufficiently tough to permit handling.

Tobacco from the field to the finished cigar, cigarette, plug or pipe tobacco, offers another interesting example of what may be done by industrial air conditioning in the control of color, texture and flavor. In the processing of tobacco, the first three classifications of air conditioning are involved, and only through close atmospheric control can the best quality of the leaf be developed.

Control Rate of Crystallization

The rate of cooling of a saturated solution determines the size of the crystals formed. Both dry- and wet-bulb temperatures are of importance, as the one controls the rate of cooling, while the other, through evaporation, changes the density of the solution.

In the coating pans for pills, gum and nuts, a heavy sugar solution is added to the tumbling mass. As the water evaporates, each separate piece is covered with crystals of sugar. A smooth, opaque coating is only accomplished by blowing into the kettle the proper amount of air at the right dry- and wet-bulb temperatures.

Elimination of Static Electricity

The presence of static electricity is very detrimental to the satisfactory and economical processing of many light materials, such as textile fibers, paper, etc. It is also extremely dangerous where explosive atmospheres or materials are present. Fortunately, this hazard is easily eliminated by increasing the relative humidity.

In attempting to eliminate static electricity, it must be borne in mind that for successful elimination the air that actually comes in contact with the material in the machine must be at a relative humidity of 50 per cent or more. As some machines consume a great deal of power which is converted directly into heat, the temperature in the machine may be considerably higher than the temperature adjacent to the machine where the relative humidity is normally measured. In such cases, the relative humidity in the machine will be appreciably lower than that elsewhere in the room, and it may be necessary to maintain a room relative humidity of 65 per cent, or even more, before the desired results can be obtained.

CALCULATIONS

The methods for determining the proper heating and cooling loads for the various industrial processes are similar to those outlined in Chapters 6 and 7. Because of the large number of motors and heat producing units

usually prevalent in an industrial application, it is particularly important that operating allowances for the latent and sensible heat loads be definitely ascertained and used in the calculations to determine the total design load.

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Chapter 40

INDUSTRIAL EXHAUST SYSTEMS

Classification of Systems, Hood Design Principles, Requirements for Suction and Velocity, Duct System Design, Collectors, Resistance of System, Efficiency of Exhaust Systems, Types of Fans, Protection Against Corrosion

IN many industries some type of exhaust system designed to collect and remove dusts and fumes is essential to the efficiency, economy, and safety of operation. General design information is included in this chapter which is intended to relate primarily to industrial exhaust systems.

CLASSIFICATION OF SYSTEMS

In general there are two basic layouts of exhaust systems, the central and the multiple unit system. In the central system a fan is located near the center of operations with a piping system radiating to the various machines to be served. In the multiple unit system, which is sometimes employed where the machines to be served are widely scattered, or where the operations are apt to be independent or intermittent, small individual exhaust fans are located at the center of the machine groups or at each machine. The unit arrangement has the advantage of flexibility.

Exhaust systems are also classified by the means employed to collect the material. The dust or refuse may be collected and controlled by enclosing hoods or open hoods with positive inward air movement or by exhausting the general air of the room. With some classes of machinery it is not feasible to hood the machines closely and in these cases open hoods over or adjacent to the machines are provided to collect as much as possible of the dust and fumes. This class includes such machines as rubber mills, package filling machinery, sand blast, crushers, forges, pickling tanks, melting furnaces, and the unloading points of various types of conveyors.

The open hoods should be placed as close to the source of dust or fumes as possible, with due regard to the movements of the operator and should be placed so that the operator is in no case in the path of the exhausted material. When the hood must be placed at some distance above the machine it should be large enough to cover a large area as diffusion is usually quite rapid.

Some consideration should be given to the natural movement of the fumes. For those that are lighter than air, the hood may be over or above

the machine; and where a heavy vapor, or dust-laden air at ordinary temperature is to be removed, horizontal or floor connections are sometimes preferable. In many cases there are convection currents and other atmospheric disturbances in the work room which should be given consideration. These disturbances diminish the tendency of dusts and fumes to settle from the room air because of their density.

In another class of operation the main objective is to prevent the escape of dust into the surrounding atmosphere, the removal of some dust from the machine or enclosure being merely incidental. The dust-creating apparatus is enclosed within a housing which is made as tight as practicable, and sufficient suction is applied to the enclosure to maintain an inward air leakage, thus preventing escape of the dust. While the exhaust system is required to handle only the air which leaks in through the crevices and openings in the enclosure, yet in many installations leakages are very high and great care is required to obtain satisfactory results with a system of this kind. The inward-leakage principle is utilized for controlling dust in the operating of tumbling barrels, grinding, screening, elevating, and similar processes.

Certain dust and fume producing operations are best carried on by isolating the process in a separate compartment or room and then applying general ventilation to this space. The compartment or room in which the work is performed should be as small as is consistent with convenience in handling the work. The ventilating system should be designed so that a current of clean air is drawn across the work in such a manner as to carry the dust or fume away from the operator and out of the work space. Another method of accomplishing the control of this type of installation is the dilution method. In this case sufficient clean air is introduced generally into the work space to dilute the contamination to a safe level.

HOOD DESIGN PRINCIPLES

The first step in the design of an exhaust system is to determine the number and size of the hoods and their connections. No general rules, however, can be given since hood and duct dimensions are determined by the characteristics of the operations to which they are applied. When a tentative decision regarding the set-up has been made, it is then necessary to obtain the suction and air velocities required to effect control. At this point the designer must rely upon the prevailing practice and on such physical data relating to hoods, duct systems and collectors as are available. The fan speed must be sufficient to maintain the estimated suction and air velocities in the system. In general, the most important requirements of an efficient exhaust and collecting system are¹:

1. Hoods, ducts, fans, motors and collectors should be of adequate size and type.
2. The air velocities should be sufficient to control and convey the materials collected.
3. The hoods and ducts should be placed so as not to interfere with the operation of a machine or any working part.
4. The system should do the required work with a minimum power consumption.

¹For more detailed requirements refer to *Fundamentals Relating to the Design and Operation of Exhaust Systems*, Z9-1936 (*American Standards Association*). Industrial Code Bulletin Nos. 10 and 12 (New York State Labor Department). *Principles of Exhaust Hood Design*, by J. M. DallaValle (*U. S. Public Health Service*, 1939).

5. When inflammable dusts and fumes are conveyed, the piping should be provided with an automatic damper in passing through a fire-wall.

6. Ducts and all metal parts should be grounded to reduce the danger of dust explosions by static electricity.

7. The design of an exhaust system should afford easy access to parts for inspection and care.

REQUIREMENTS FOR SUCTION AND VELOCITY

The removal of dust or waste by means of an exhaust hood requires a movement of air at the point of origin sufficient to carry it into a collecting system. The air velocities necessary to accomplish this depend upon the physical properties of the material to be eliminated and the direction and speed with which it is thrown off. If the dust to be removed is already in motion, as is the case with high-speed grinding wheels, the hood must be installed in the path of the particles so that a minimum air volume may be used effectively. It is always desirable to design and locate a hood so that the volume of air necessary to produce results is as small as possible. This will reduce the size of equipment and power required by the system and also the heating load requirements in the winter.

Air Flow from Static Readings

The static suction at the throat of a hood is frequently used in practice as a measure of the effectiveness of control. Where the hood coefficient is known the volume of air flow through any hood may be determined from the equation:

$$Q = 4005 f A \sqrt{h_t} \quad (1)$$

where

Q = volume of air flow, cubic feet per minute.

A = area of connecting duct, square feet.

h_t = static suction measured 3 diameters from throat of hood, inches of water.

f = orifice or restriction coefficient which varies from 0.6 to 0.9 depending on the shape of the hood.

An average value of f is 0.71, although for a well-shaped opening a value of 0.8 may be used. The factor f is determined from the equation:

$$f = \sqrt{\frac{h_v}{h_t}} \quad (2)$$

where h_v is the velocity head in the connecting duct.

The *static suction* is not a good measure of the effectiveness of a hood

TABLE 1. RATES OF FLOW THROUGH BRANCH PIPES WOODWORKING MACHINES

PIPE DIAMETER, IN.	AIR VOLUME, CFM
3	200
4	350
5	550
6	800
7	1100
8	1400

unless the area of the opening and the location of the operation with respect to the hood are known. This is clearly indicated by Equation 3 which shows that the velocity at any point along the axis varies approximately inversely as the square of the distance. However, this formula coupled with Equation 1 should serve to indicate the velocity conditions to be expected when operations are conducted external to the hood opening.

TABLE 2. BRANCH PIPE SIZE FOR WOODWORKING MACHINE HOODS

TYPE OF MACHINE	SIZE, IN.		NO. OF BRANCHES	MINIMUM DIAMETER, IN.		
	Min.	Max.		BOTTOM BRANCH	TOP BRANCH	OTHERS
Self feed table saw			2	5	4	
Other single saws	18	18	1 1		4 5	
Saws with Dado Head			1		5	
Band saws		2	2	4	4	
	2	3	2	5	4	
	3	6	2	5	5	
Disc sanders		18	1	4		
	18	28	1	5		
	26	32	2	4	4	
	32	38	2	5	4	
	38	48	3	5	4	4
Triple drum sanders		30	1	7		
	30	36	1	8		
	36	42	1	9		
	42	48	1	10		
Single drum sanders: (area in sq in.)		350	1	4 ^a		
	350	700		5		
	700	1400		6		
	1400	2800		7		
Horizontal belt sanders		9	2	5	4	
	9	14	2	6	4	
Vertical belt sanders		6	1	4		
	6	9	1	5		
	9	14	1	6		
Jointers		8	1	4		
	8	20	1	5		
Single planers		20	1	5		
	20	26	1	6		
	26	36	1	7		
Tenoner			2	5	5	

^aNot over 10 in. diameter.

CHAPTER 40. INDUSTRIAL EXHAUST SYSTEMS

TABLE 3. RATES OF FLOW THROUGH BRANCH PIPES GRINDING AND BUFFING WHEELS

PIPE DIAMETER, IN.	AIR VOLUME, CFM
3	225
4	400
5	600
6	900
7	1200

Design Based on Total Air Flow

Where the foregoing factors are not known, the usual method of designing an exhaust system is to base the air flow through the system on rates of flow through each hood which have been found by experience to provide adequate control. For woodworking systems the rates of flow given in Table 1, calculated on the basis of a branch velocity of 4000 fpm, are adequate for control. Using these air flow rates, Table 2 gives the size of pipe connections to be used with the more common woodworking machines. Properly designed grinding and buffing wheel hoods have been found to be adequately controlled when the rates of air flow given in Table 3, calculated on the basis of a branch velocity of 4500 fpm, are used. Table 4 gives the minimum branch pipe sizes to be used on the more common sizes of grinding and buffing wheels.

In some states grinding, polishing and buffing wheels are subject to regulation by codes. (See Standards Chapter 48.) The static suction requirements, which range from $1\frac{1}{2}$ to 5 in. water displacement in a U-tube, must be followed in such states although in several instances they may appear to be excessive. Frequently, in these operations, a large part of the wheel must be exposed and the dust-laden air within the hood is thrown outward by the centrifugal action of the wheel, thus counteracting useful inward draft. This tendency may be diminished by locating the connecting duct so as to create an air flow of not less than 200 fpm past the lower edge of the wheel.

TABLE 4. BRANCH PIPE SIZES FOR GRINDING AND BUFFING HOODS

TYPE OF WHEEL	WHEEL SIZE DIAMETER, IN.		MAXIMUM		BRANCH PIPE MINIMUM DIAMETER, IN.
	Min.	Max.	Width In.	Area Sq In.	
Grinding	----	9	1	30	3
	9	18	3	175	4
	18	24	4	300	5
	24	30	5	500	6
	30	36	6	700	7
Disc Grinding	----	20	----	300	4
	20	30	----	----	5
Buffing, Polishing and Scratch Brushing	----	8	2	50	$3\frac{1}{2}$
	8	16	3	150	4
	16	24	4	300	5
	24	30	6	600	6

Controlling Air Velocities

Exact determinations of hood control velocities are not available, but it is safe to assume that for most dusty operations they should not be less than 200 fpm at the point of origin. For granite dust generated by pneumatic devices, velocities from 150 to 200 fpm, depending on the type of hood used, are recommended as sufficient for safe control². Considering the character of the industry, air velocities of this order may be extended to similar dusty operations. The method for approximately determining these velocities in terms of the velocity at the hood opening is given in Equation 3.

No set rule can be given regarding the shape of a hood for a particular operation, but it is well to remember that its essential function is to create an adequate velocity distribution. The fact that the zone of greatest effectiveness does not extend laterally from the edges of the opening may frequently be utilized in estimating the size of hood required. Where complete enclosure of a dusty operation is contemplated, it is desirable to leave enough free space to equal the area of the connecting duct. Hoods for grinding, polishing and buffing should fit closely, but at the same time should provide an easy means for changing the wheels. It is advisable to design these hoods with a removable hopper at the base to capture the heavy dust and articles dropped by the operator. Such provisions are of assistance in keeping the ducts clear. Air volumes used to control many dust discharges may often be reduced by effective baffling or partial enclosure of an operation. This procedure is strongly urged where dusts are directed beyond the zone of influence of the hood.

Axial Velocity Formula for Hoods

When the normal flow of air into a hood is unobstructed, Equation 3 may be used to determine the air velocity at any point along the axis³:

$$V = \frac{0.1 Q}{x^2 + 0.1 A} \quad (3)$$

where

V = velocity at point, feet per minute.

Q = volume of air handled, cubic feet per minute.

x = distance along axis, feet.

A = area of opening, square feet.

Velocity Contours

It is possible by use of a specially constructed Pitot tube⁴ to map contours of equal velocity in any axial plane located in the field of influence. It has been found that the positions of these contours for any hood can be expressed as percentages of the velocity at the hood opening and are purely functions of the shape of the hood⁵.

²Control of the Silicosis Hazard in the Hard Rock Industries. I. A Laboratory Study of the Design of Dust Control Systems for Use with Pneumatic Granite Cutting Tools, by Theodore Hatch, Philip Drinker and Sarah P. Choate. (*Journal of Industrial Hygiene*, Vol. XII, No. 3, March, 1930).

³The Control of Industrial Dust, by J. M. DallaValle (*Mechanical Engineering*, Vol. 55, No. 10, October, 1933).

⁴Studies in the Design of Local Exhaust Hoods, by J. M. DallaValle and Theodore Hatch (*A.S.M.E. Transactions*, Vol. 54, 1932)

⁵Velocity Characteristics of Hoods under Suction, by J. M. DallaValle (*A.S.H.V.E. TRANSACTIONS*, Vol. 38, 1932, p. 387).

Further, the velocity contours are identical for similar hood shapes when the hoods are reduced to the same basis of comparison. These facts are applicable to all hood problems so that when the velocity contour distribution is known, the air flow required can be determined. Fig. 1 shows the contour distribution in two axial planes perpendicular to the sides of a rectangular hood with a side ratio of one-half. The distribution shown is identical for all openings with a similar side ratio provided the mapping is as shown in the figure. The contours, of course, are expressed as percentages of the velocity at the opening.

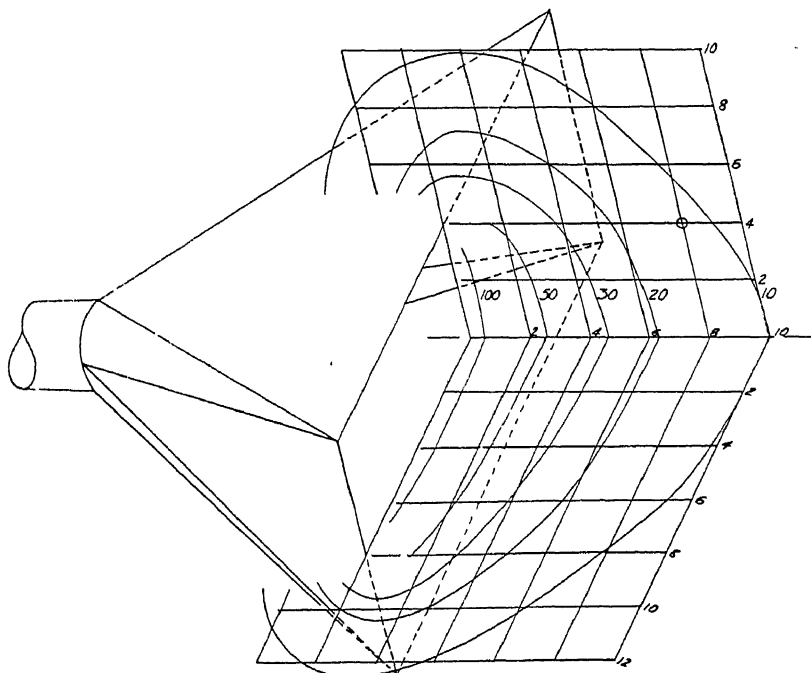


FIG. 1. VELOCITY CONTOURS FOR A RECTANGULAR OPENING WITH A SIDE RATIO OF ONE-HALF. CONTOURS ARE EXPRESSED AS PERCENTAGES OF THE VELOCITY AT THE OPENING

Low Velocity Systems

On multiple installations of the same operation it is often possible to institute a great saving in power cost by designing an exhaust system using low velocities in the main ducts. Such a system for use in grinding and shaping porcelain has been described⁶. In these operations, the separate machines are grouped around a central plenum chamber and exhausted by means of a low pressure fan connected to the plenum. In this case a power saving of over 90 per cent was obtained. A similar design technique has been described⁷ for use in ventilating plating tanks.

⁶Low Velocity Exhaust Systems, by Theodore Hatch (*Heating and Ventilating*, October, 1940, p. 27).

⁷Tank Ventilating Power Costs Cut by Low Velocity Systems, by William B. Harris (*Heating and Ventilating*, July, 1942, p. 42).

Large Open Hoods

Large hoods, such as may be used for electroplating and pickling tanks, should be sub-divided so the area of the connecting duct is not less than one-fifteenth of the open area of the hood. Frequently, it will be found necessary to branch the main duct in order to obtain a uniform distribution of flow. *Canopy hoods* should extend 6 in. laterally from the tank for every 12 in. elevation, and wherever possible they should have side and rear aprons so as to prevent short circuiting of air from spaces not directly over the vats or tanks. In most cases, hoods of this type take advantage of the natural tendency of the vapors to rise, and air velocities may be kept low. Cross drafts from open doors or windows disturb the rise of the vapors and therefore provision must be made for them. The air velocities required also depend upon the character of the vapors given off, cyanide fumes, for example, requiring an air velocity of approximately 75 fpm on the surface of the tank and acid and steam vapors requiring velocities as low as 25 to 50 fpm. The total volume of air flow necessary to obtain these velocities may be approximately determined from the equation:

$$Q = 1.4 PDV \quad (4)$$

where

Q = total volume of air handled by hood, cubic feet per minute.

P = perimeter of the tank, feet.

D = distance between tank and hood opening, feet.

V = air velocity desired along edges and surface of tank, feet per minute.

Lateral Exhaust Systems

The lateral exhaust method, as developed for chromium plating⁸, is applicable in many instances in preference to the canopy type hoods. The method makes use of drawing air and fumes laterally across the top of vats or tanks into slotted ducts at the top and extending fully along one or more sides of the tanks. The slots are 1 in. wide and for effective ventilation a 2000 fpm exhaust air velocity at the slot face is advisable. In addition, the duct should not be required to draw the air laterally for a distance of more than 18 in. and the level of the solution should be kept 6 to 8 in. below the top of the tanks.

It has also been determined that a similar control may be used for tanks wider than 3 ft when the same velocity (2000 fpm) is maintained through a slot which is increased $\frac{1}{4}$ in. for every foot of width greater than 3 ft. When these slots must be extended more than 6 ft in length some method of spreading the flow is necessary to provide even air flow distribution through the entire slot length. This can be accomplished by tapering the slot, which incidentally will add to the resistance of the system. A more economical approach is to place properly spaced vanes in the side ducts, or to branch the side ducts⁹.

The flexible exhaust tube method may be advantageously used for

⁸Health Hazards in Chromium Plating, by J. J. Bloomfield and William Blum (*U. S. Public Health Report*, Vol. 43, No. 26, September 7, 1928).

⁹New Data for Practical Design of Ventilation for Electroplating, by W. P. Battista, Theodore Hatch and Leonard Greenburg (*Heating, Piping and Air Conditioning*, February, 1941, p. 81). Ventilation of Plating Tanks, by Allen D. Brandt (*Heating, Piping and Air Conditioning*, July, 1941, p. 434).

removing dust or fumes. Flexible tubes having one end connected to an exhaust system and a slotted hood attached to the other end may be shaped at will to fit in with industrial processes without affecting the ease of operation. Efficient dust or fume removal may be had with use of relatively small exhaust volumes. This type of system may be used on swing grinders, portable grinding wheels, soldering operations, stone cutting, rock drilling, etc.

Spray Booths

In the design of an efficient spray booth, it is essential to maintain an even distribution of air flow through the opening and about the object being sprayed. While in many instances spraying operations can be performed mechanically in wholly enclosed booths, the volatile vapors may reach injurious or explosive concentrations. At all times the concentrations of these vapors, and particularly those containing benzol, should be kept well below 100 parts per million in the breathing zone of the worker. Spray booth vapors are dangerous to the health of the worker and care should be taken to minimize exposure to them.

It is recommended in the design of spray booths that the exhaust duct be located at the end of the booth opposite the opening. In front of this duct should be placed baffle plates which will cause a uniform air velocity distribution across the frontal area. The air volume should be sufficient to maintain a velocity of not less than 100 fpm over the open area of the booth (150 fpm is preferable where benzol or lead is present in the paint) and the vapors should be discharged through a suitable stack to permit dilution. It is good practice to pass the fumes or vapors through baffle type washers or scrubbers designed for efficient spray removal.

Hoods for Chemical Laboratories

Hoods used in chemical laboratories are generally provided with sliding windows which permit positive control of the fumes and vapors evolved by the apparatus. Their design should offer easy access for the installation of chemical equipment and should be well lighted. Air velocities should exceed 50 fpm when the window is opened to its maximum height.

Kitchen Hoods

The length and width of kitchen hoods should be such as to extend beyond the extreme projection of the ranges, broilers, etc., over which they are installed. The minimum projection or overlap should be 12 in. Where space conditions permit, range hoods should be about 2 ft high so as to provide a reservoir to confine momentary bursts of smoke and steam until the exhaust system can evacuate the hood. As in the case of industrial hoods, range hoods should be located as low as possible to increase their effectiveness.

In general the amount of air to be exhausted from restaurant range hoods is at the rate of 100 fpm per square foot of face area. Thus, a hood 4.5 ft wide by 30 ft long has a face area of 135 sq ft, which multiplied by 100 fpm velocity results in a total air quantity to be exhausted of 13,500 cfm. In some cases where the application is principally frying and where

it is not practical to install a hood 2 ft high it is recommended that the face velocity be increased from 100 to 150 fpm, depending on peak load conditions in the kitchen. Exhaust connections to range hoods should always be made at the top and back of hoods, and should be spaced preferably not more than 6 ft apart and be rectangular in shape with the long side parallel to the back of the hood. Exhaust openings into range hoods should be designed to maintain a velocity of 1500 to 1800 fpm.

An approved fire damper with fusible link should be (and is required by code in many states) installed in the main exhaust duct or branch adjacent to the range hood. Should there be more than one hood connected to a common duct, then the branch duct to each hood should be provided with a fire damper. Access doors should be provided at the fire damper for purpose of inspection, cleaning or for renewal of fusible link. All exhaust piping to range hoods, commonly called grease ducts, should be provided with tight fitting cleanout doors of adequate size to permit easy removal of grease.

Hoods over steam tables should be of similar construction to range hoods. In determining the necessary amount of air to be exhausted it is considered good practice to design such hoods with a face velocity of 60 to 70 fpm. Hoods over dishwashing machines are usually relatively small and generally 1500 to 2000 cfm per hood is allowed, which is equivalent to a velocity of approximately 100 fpm per square foot of face area. Range hoods in diet kitchens are constructed the same as restaurant range hoods but with less exhaust air per square foot of face area, depending upon the nature of the food cooked.

Hoods are not often used in private residences unless they are quite large and the consideration of expense is not important. For such residences the hoods should be designed on the same basis as diet kitchens. Most all residence kitchens can be effectively and economically ventilated by the installation of a built-in kitchen ventilator, which should be located in an outside wall and in close proximity to the kitchen range. It has been found that the capacity of the built-in kitchen ventilator should be at least 350 cfm regardless of the size of kitchen. This can be justified on the basis that the smaller the kitchen the more concentrated the heat will be thus requiring a more rapid rate of air change. Standard size built-in kitchen ventilators are generally available in three sizes, namely 350, 500 and 800 cfm. The proper size to use will depend on design conditions and available wall space.

DUCT SYSTEM DESIGN

In designing a duct system it is necessary to recognize a few fundamental principles (see also Chapter 32). Knowing the quantity of air required, the size of the duct may be computed from Equation 5:

$$A = \frac{Q}{V} \quad (5)$$

A = cross-section area of duct, square feet.

Q = air quantity to be handled by the duct, cubic feet per minute.

V = velocity of air, feet per minute.

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TABLE 5. GAGES OF METALS FOR EXHAUST SYSTEM

DUCT DIAMETER, IN	GAGE OF METAL	
	Dust	Non-Corrosive Fumes, Vapors and Gases
8 or less.....	20	24
9 to 18.....	18	22
18 to 30.....	16	20
30 or more.....	14	18

Air Velocities in Ducts

Where it is necessary to transport the particulate material collected in an exhaust system, minimum carrying velocities must be maintained in the ducts preceding the collector. It has been found that good design results when air velocities in horizontal runs are not less than 3000 fpm or not greater than 5000 fpm. When the dust being carried is organic and other than wood flour, or similar material, a velocity of 2500 fpm is adequate. The velocity in vertical piping should be increased 25 per cent over the minimum required for transport in horizontal ducts.

For duct systems wherein the air has no dust or solid load, a lower velocity is desirable, which may range from 1200 to 2000 fpm. In view of the fact that the horsepower required by a system depends directly on the resistance and the resistance is a function of the velocity, economical design requires velocities of this magnitude.

The equal friction method is generally used for designing a duct system as this insures equal resistance to air flow in all branches throughout the system (see Chapter 32). Long main ducts do not generally provide the most economical layout. Where it is necessary to ventilate a large number of machines, or machines which are widely separated, it is desirable to locate the fan at approximately the center of the system. With this arrangement it is possible to choose a fan which will deliver the required air quantity against a lower resistance pressure, and this will generally result in a horsepower saving.

When a system carrying dust is designed with an oversize main duct to allow for future extension, the air velocity may be found to be too low to carry the dust, and serious plugging may occur. In this case it is desirable to install an orifice in the end of the pipe to allow for the lower air quantity.

Construction

The ducts leading from the hoods to the exhaust fan should be constructed of sheet metal not lighter than is shown in Table 5. The piping should be free from dents, fins and projections on which refuse might catch.

All permanent circular joints should be lap-jointed, riveted and soldered, and all longitudinal joints either grooved and locked or riveted and soldered. Circular laps should be in the direction of the flow, and piping installed out-of-doors should not have the longitudinal laps at the bottom. Every change in pipe size should be made with an eccentric taper flat on the bottom, the taper to be at least 4 in. long for each inch

change in diameter. All pipes passing through roofs should be equipped with collars so arranged as to prevent water leaking into the building.

The main trunks and branch pipes should be as short and straight as possible, strongly supported, and with the dead ends capped to permit inspection and cleaning. All branch pipes should join the main at an angle of not greater than 45 deg, the junction being at the side or top of the larger end of a transformation piece. Branch pipes should not join the main pipes at points where the material from one branch would tend to enter the branch on the opposite side of the main.

Cleanout openings having suitable covers should be placed in the main and branch pipes so that every part of the system can be easily reached in case the system clogs. Either a large cleanout door should be placed in the main suction pipe near the fan inlet, or a detachable section of pipe, held in place by lug bands, may be provided.

Elbows and hoods should be made at least two gages heavier than straight pipe of the same diameter, in order to enable them to withstand the additional wear caused by changing the direction of flow. Elbows should preferably have a throat radius of at least one and one-half times the diameter of the pipe.

Every pipe should be kept open and unobstructed throughout its entire length, and no fixed screen should be placed in it, although the use of a trap at the junction of the hood and branch pipe is permissible, provided it is not allowed to fill up completely. The passing of pipes through firewalls should be avoided wherever possible, and floor sweep connections should be so arranged that foreign material cannot be easily introduced into them.

At the point of entrance of a branch pipe with the main duct, there should be an increase in the latter equal to their sum. Some state codes specify that the combined area be increased by 25 per cent. While this is not always good practice and is frequently done at the expense of a reduced air velocity, it is often done where future expansion of the exhaust system is contemplated.

Duct Resistance

The resistance to flow in any galvanized duct riveted and soldered at the joints may be obtained from Fig. 2, Chapter 32. The pressure drop through elbows depends upon the radius of the bend. For elbows whose centerline radii vary from 50 to 300 per cent of pipe diameter, the loss may be estimated from Table 6. It is sometimes convenient to express the resistance of an elbow in terms of an equivalent length of duct of the same diameter. Thus with a throat radius equal to the pipe diameter the resistance is equivalent to a section of straight pipe approximately 10 diameters long, while with a throat diameter radius $1\frac{1}{2}$ times the diameter, the resistance is apparently the same as that of seven diameters of straight pipe.

COLLECTORS

The most common method of separating the dust and other materials from the air is to pass the mixture through a centrifugal or *cyclone* col-

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TABLE 6. LOSS THROUGH 90-DEG ELBOWS

ELBOW CENTER LINE RADIUS IN PER CENT OF PIPE DIAMETER	LOSS IN PER CENT OF VELOCITY HEAD
50	75
100	26
150	17
200 to 300	14

lector. In this type of collector the mixture of the air and material is introduced on a tangent, near the cylindrical top of the collector, and the whirling motion sets up a centrifugal action causing the comparatively heavy materials suspended in the air to be thrown against the side of the separator, from which position they spiral down to the tail piece, while the air escapes through the stack at the center of the collector.

The diameter of the cyclone should be at least 3.5 times the diameter of the fan discharge duct. When two or more separate ducts enter a cyclone, gates should be provided to prevent any back draft through a system which may not be operating. Cyclones working in conjunction with two or more fans should be designed to operate efficiently at two-thirds capacity rating.

If a cyclone is used to collect light dusts such as buffing wheel dusts, feathers and lint, the exhaust vent should be large enough to permit an air velocity of 200 to 500 fpm. This will require a cyclone of larger dimensions than given for the foregoing general case.

When a high collection efficiency is desired, or the material is very fine, multi-cyclones may be used. These are merely small cyclones arranged in parallel which utilize the principle of high centrifugal velocity to attain separation. The capacities and characteristics of this type of separator should be obtained from the manufacturers.

Dust Filters

Filters are used when the material collected by an exhaust system is valuable or cannot be separated efficiently from the air with an ordinary cyclone. They are also employed when it is desirable to recirculate the air drawn from a room by the exhaust system, which otherwise might entail considerable loss in heat. Bag filters which are properly housed should be operated under suction. *Bag houses* used in the manufacture of zinc oxide and other chemical products are operated on the positive side of the fan.

Wool, cotton and asbestos cloths, and paper are commonly used as filtering mediums. When woolen cloths are employed, the filtering capacities vary from $\frac{1}{2}$ to 10 cfm per square foot of filtering surface, depending on the character of the material collected. The rates for cotton and asbestos cloths are lower. The type of filter cloth and the rates of filtration depend, of course, on the material to be collected and the fan capacity. The time increase of resistance varies with the amount of material permitted to build up on the surface of the filter and can be determined only by experiment. The limits of the increase may be regulated by adjustment of the shaking or cleaning mechanism. These

limits may be regulated further according to the capacity of the fan and the effective performance of the hoods and the duct system.

For additional information on dust and cinders, see Chapter 29, Air Cleaning Devices.

RESISTANCE OF SYSTEM

The maintained resistance of the exhaust system is composed of three factors: (1) loss through the hoods, (2) collector drop, and (3) friction drop in the duct system.

The loss through the hoods is usually assumed to be equal to the suction maintained at the hoods. Where possible the resistance of the particular collector to be used should be ascertained from the manufacturer.

Friction drop in the pipes must be computed for each section where there is a change in area or in velocity. Find the velocities in each section of pipe starting with the branch most remote from the fan. The friction drop for these sections can be determined by reference to Table 6 and Fig. 2, Chapter 32. Total friction loss in the piping system is the friction

TABLE 7. ACCEPTED STANDARDS FOR TOXIC CONCENTRATION OF FUMES, DUSTS AND MISTS^a

FUMES	MILLIGRAMS PER CUBIC METER
Cadmium oxide.....	0.1
Chlorodiphenyl.....	1.0
Lead or oxides of lead.....	0.15
Mercury or mercury compounds.....	0.1
Pentachloronaphthalene.....	0.5
Trichloronaphthalene.....	5.0
Zinc oxide.....	15.0
DUSTS	MILLION PARTICLES PER CUBIC FOOT ^b
Asbestos.....	5
Cement.....	100
Gypsum.....	100
Lead or compounds of lead.....	0.15 ^c
Manganese.....	6 ^c
Marble.....	100
Silica (more than 70 per cent free silicon-dioxide).....	5
Silica (more than 10 per cent free silicon-dioxide).....	10
Silica (less than 10 per cent free silicon-dioxide).....	100
MISTS	MILLIGRAMS PER CUBIC METER
Chromic acid.....	0.1
Sulphuric acid.....	5.0

^aAdapted from Safe Concentrations of Certain Common Toxic Substances Used in Industry, by M. Bowditch, C. K. Drinker, P. Drinker, H. A. Haggard, and H. Hamilton (*Journal of Industrial Hygiene and Toxicology*, Vol. 22, No. 6, June, 1940). Industrial Code Bulletin No. 35 (New York State Labor Department). Study of Asbestosis in Asbestos Textile Industry (*U. S. Public Health Bulletin* No. 241, 1938). Chronic Manganese Poisoning in an Ore Crushing Mill (*U. S. Public Health Bulletin* No. 247, 1940).

^bDetermined by light field or equivalent technique.

^cMilligrams per cubic meter.

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TABLE 8. CORROSION RESISTING MATERIALS FOR EXHAUST SYSTEMS^a

MATERIAL	ACID ^b																
	ACETIC		CHROMIC		HYDRO-CHLORIC		HYDRO-FLUORIC		NITRIC		PHOS- PHORIC		SUL- PHUROUS		SUL- PHURIC		
METALS	Dil.	Conc.	Dil.	Conc.	Dil.	Conc.	Dil.	Conc.	Dil.	Conc.	Dil.	Conc.	Dil.	Conc.	Dil.	Conc.	
Aluminum.....	Good		Fair		Poor		No Data		Poor		Good		Poor		Poor		
Magnesium and Alloys....	No Data		Good		Poor		No Data		Poor		Good		No Data		No Data		
Lead and Lead-Coated ...	Poor		Good		Poor		Poor		Poor		Poor		Good		Good		
Moly Alloy (60 Ni—20Mo—20 Fe).....	Good		No Data		Fair		No Data		Poor		Poor		No Data		Good		
Monel Metal.....	Fair		Poor		Fair		Poor		Good		Fair		Poor		Good		
Bronze.....	Poor												Good				
Silicon Iron	Fair		Good		No Data		Fair		Poor		Good		Good		No Data		
Stainless Steel ^c (18 Cr—8 Ni).....	Good		Good		Poor		No Data		Good		Poor		Good		Poor		
Enameled Steel.....	No Data		No Data		Good		Poor		Good		Poor		No Data		Good		
MISCELLANEOUS																	
Asbestos Comp.....					Good except against strong acids and alkalis												
Wood.....	Some woods are decomposed or softened faster than others.																
Rubber.....									Poor						Poor		
Plastics.....	In general plastics resist weak acids and are decomposed by concentrated acid.																

^aStandard Practice Sheet No. 115 (Division of Industrial Hygiene, New York State Labor Department)

^bAcid mists in air are more corrosive than as liquid in storage tank. Galvanized iron not resistant to acid.

^cStainless steel of (24 Cr—10 Ni) fairly resistant at low temperature for HCl and H_3PO_4 .

^dUnder most conditions.

^eAt room temperatures.

drop in the most remote branch plus the drop in the various sections of the main, plus the drop in the discharge pipe.

EFFICIENCY OF EXHAUST SYSTEMS

The efficiency of an exhaust system depends upon its effectiveness in reducing the concentration of dusts, fumes, vapors and gases below the safe or threshold limits¹⁰.

Too much emphasis cannot be placed on the necessity of testing exhaust systems frequently by determining the concentration of atmospheric contamination at the worker's breathing level. Commonly accepted values of threshold limits for usual atmospheric contaminants, such as fumes, dusts and mists are given in Table 7. Similar data covering gases and vapor will be found in Chapter 28.

¹⁰Criteria for Industrial Exhaust Systems, by J. J. Bloomfield (A.S.H.V.E. TRANSACTIONS, Vol. 40, 1934, p. 353).

TYPES OF FANS

Manufacturers generally provide special fans for the collection of various industrial wastes. These are available for the collection of coal dust, wood shavings, wool, cotton and many other substances. When substances having an abrasive character are conveyed, the fan blades and housing should be protected from wear. This may be accomplished by placing a collector on the negative side of the fan or by lining the housing and blades with rubber.

PROTECTION AGAINST CORROSION

The removal of gases and fumes in many chemical plants requires that metals used in the construction of the exhaust system be resistant to chemical corrosion. A list of the materials which may be used to resist the action of certain fumes is given in Table 8. Hoods and ducts, when short, may frequently be constructed of wood and be quite effective. Rubberized paints are available and may be applied as protective coatings in handling such gases and fumes as chlorine and hydrochloric acid.

Chapter 41

DRYING SYSTEMS

Drying Methods, Radiant-Heat Drying, Conduction or Direct Contact Drying, Convection or Air Drying, Mechanism of Drying, Omissions in the Cycle, General Rules for Drying, Humidity Chart, Dryer Calculations, Design, Estimating Methods

DRYING, in its broader sense, refers to the removal of water, or other volatile liquid from either a gaseous, liquid, or solid material. In practice, the process of direct drying gaseous material is referred to generally as dehumidifying, or condensing, and in some cases chemicals are used in the adsorption or absorption of moisture. The subjects of dehumidification and dehydration are treated in Chapter 24. Drying a liquid is called evaporation or distillation. The common usage of the word *drying* refers to the removal of water or other liquid, such as a solvent, by evaporation from a solid material.

When the solid to be dried contains large amounts of free water, the actual drying process is frequently preceded by the removal of part of the water by some mechanical means, such as filtration, settling, pressing or centrifuging. Removal of as much water as possible by such methods is usually advisable, as the cost of these operations, per pound of water removed, is generally much less than by evaporation. In some drying processes the evaporation of the liquid is accompanied by a chemical change, as in the drying of paint and varnish.

DRYING METHODS

Heat must be supplied in order to dry a solid by evaporation. Since this latent heat is large compared with the specific heat of the materials, drying becomes largely a problem in heat transfer. Hence drying methods are often classified according to the method of heat transfer used, as follows:

1. Radiant-heat drying.
2. Drying by direct contact, and conduction.
3. Convection or air drying.

Radiant-Heat Drying

Drying by sun heat is still practiced where danger of rain is slight, atmospheric pollution is negligible and sufficient time can be allowed.

Radiating surfaces, (heated by steam, electricity or other means), afford a good method of heat distribution and control. Radiant heating sets up

TABLE 1. DRYERS FOR EVAPORATION OF WATER

Type	Kind	Materials Handled	Means of Handling	Temp. Range Deg F	Heat Supply	Uses and Remarks
Batch or Intermittent	Compartment	Paper, Leather, Yarns, Lumber, Foodstuffs	Suspended, Truck, Tray	80 to 180	Steam Coils, Air, Electricity	When production does not warrant continuous drier
	Agitated	Chemicals too sticky for Rotary Drier	Shoveled into Drum or Pan	100 to 330	Water, Steam Jacketed, may have Vacuum on top	Where dust must be saved
	Vacuum	Chemicals, Explosives, Pharmaceuticals, Food Products	Tray Basket, Tumbling Drum	80 to 300	Water, Steam	Cost of operation high, for expensive materials
	Tunnel	Ceramics, Chemicals, Lumber, Food Products	Truck, Tray, Belt	100 to 350	Steam Coils, Air, Electricity, Products of Combustion	For high production
Continuous	Rotary	Bulk	Cascades through	80 to 500	Air, Steam, Products of Combustion	Where material will stand rough handling and is not subject to balling up
	Drum	Liquids, Slurries	Flowed on Drum, Dry Material Scraped off	to 310	Steam, may have Vacuum on Top	Hygroscopic materials dried with vacuum, and packed immediately
	Cylinder	Paper, Textiles, Chemicals	Continuous Sheets, Endless Chain Belt	to 350	Steam inside of Drum	Where material comes in sheets or rolls, and will stand direct contact with heating surface
	Festoon	Paper, Chemicals	Continuous Sheets, Suspended on Metal Screens	to 200	Air, Steam Coils	Where one side cannot come in contact with supports until dry
	Tower or Column	Grains, Sand	Falls through by Gravity	125 to 250	Air, Steam Coils	Where headroom is available
	Spray	Solutions over 30% Solids	Sprayed into Chamber	120 to 350	Air, Products of Combustion	Drying is almost instantaneous
	Induction	Metals, for removal of traces of Water	Placed in High Frequency Field	to 400	Electricity	Where heating of metal from inside out is important

convection currents, and in low-temperature dryers only about one-third to one-half of the total heat for evaporation is actually supplied to the material by radiation. At high temperatures the radiation output increases rapidly, according to the *fourth-power law*. The total radiation may be computed by the equations and tables given in Chapter 3. In general, fins and irregular surfaces do not increase radiation, hence the area to be used in calculations is the area of a smooth-surface envelope enclosing the radiating elements.

A certain amount of air circulation is required through a radiant dryer, in order to carry off the vapor.

Conduction or Direct Contact Drying

Drying rolls or drums, flat surfaces, open kettles and immersion heaters are examples of the direct-contact method. Intimate contact of the material with the heating surface is important, and in some cases agitation

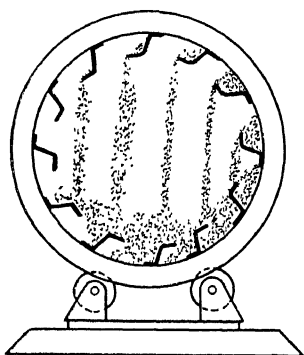


FIG. 1. SECTION OF ROTARY DRYER

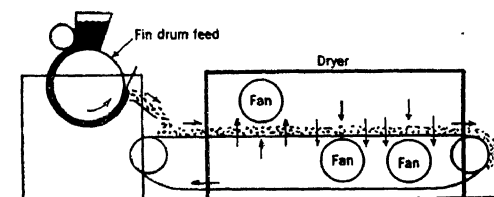


FIG. 2. SECTION OF CONTINUOUS DRYER, BLOW-THROUGH TYPE

is desirable to increase the uniformity of heating or to prevent overheating.

Greatest resistance to heat transfer occurs on the air side of the material being dried. The rate of heat transfer from the surface of the heated material to the air, and hence the rate of drying, may be increased by: (a) forced convection or air circulation and (b) vacuum operation to lower the boiling point of the liquid being evaporated.

Convection or Air Drying

The circulation of heated air or other gases over the material being dried is termed convection drying. Some convection drying occurs in practically all types of dryers, but if the main source of heat is from the air or gases, the dryer may be called a convection dryer. Typical forms or examples may be enumerated:

1. Rotary drum dryers, (Fig. 1).
2. Tunnel or oven dryers, batch type.
3. Tunnel dryers, conveyor type, (Figs. 3 and 4).
4. Tower or column dryers.
5. Through-circulation dryers, (Fig. 2).

In any type of convection dryer the heat transfer and hence the drying depends primarily upon the surface area of material exposed to the air and the velocity of the air over the surfaces (see Dryer Calculations, later).

A general classification of several types of dryers is given in Table 1. The chief basis of classification in this table is that of intermittent or batch operation as opposed to continuous operation. Another important basis of classification would be the method of handling the material to be dried. In an effort to secure maximum contact of the air with the product, as well as uniformity of heating, the effectiveness of cascading the material in an inclined drum or of blowing heated air through a bed of granular or pre-formed material is at once apparent, and where continuous drying at high capacity is required, these types are preferred. Extensive experimental studies on both types are available, (see References).

Simple *drying ovens* are often used for drying smaller quantities of material.

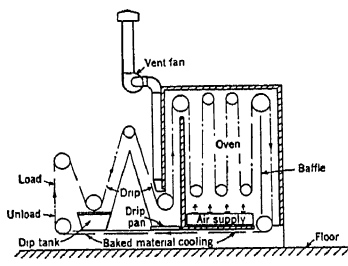


FIG. 3. SMALL PART MULTIPLE PASS OVEN

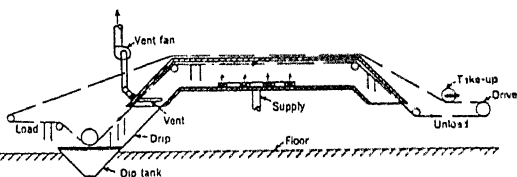


FIG. 4. INCLINED END ENAMELING OVEN

The *heat and humidity supply* for low temperature work up to 250 F is often steam; steam coils either in the oven or outside, heat the air used for drying. Circulation of heated oil is used to a limited extent, but the danger of leaks is serious, for if the oil is hotter than the flash point, a fire may start if the oil is released to the atmosphere. In many cases where steam is not available, direct or indirect-fired heaters are used with gas or oil as fuel. Indirect heaters should be carefully selected from a standpoint of long life and efficiency. The heat exchange surface should be adequate in area and easily accessible for cleaning and removal. For extremely high temperatures, alloy surface may be used. With direct-fired equipment care must be used in the selection of burners and sufficient combustion space allowed to insure complete combustion of fuel. Humidity can be obtained in dryers by the use of steam spray, humidifiers, or recirculation.

For low temperature work up to 200 F ovens and dryers are commonly built of two thicknesses of insulating board (fireproof preferred), with air space between. As the temperature increases materials better able to withstand the heat must be used. Metal lined ovens are easy to keep clean, and many high temperature dryers up to 1000 F are made of metal

panels with insulation between. Care should be taken to avoid *through metal* (metal extending through the oven wall from inside to out). Batch type ovens are entirely closed while in use and control of air leakage is easily taken care of. In the continuous dryer where the ends are open, heat and air leakage becomes important. Warm air leaking out of the ends of ovens means a heat loss, and often the temperature and humidity outside the oven becomes unbearable. For this reason, inclined or bottom entry ovens are used, as the warm air leakage can be more easily controlled. See Figs. 3 and 4.

MECHANISM OF DRYING

The modern theory of drying may be summed up as follows: Assuming uniform velocity and distribution of air at a constant temperature and

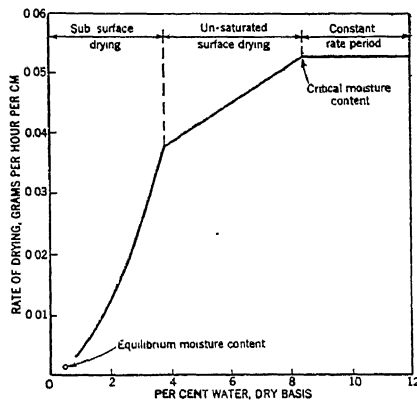


FIG. 5. RATE OF DRYING OF WHITING SLAB

humidity over the surface to be dried, the drying cycle will be divided into two distinct stages:

1. Constant rate period.
2. Falling rate period.

The *constant rate period* occurs while the material being dried is still very wet, and continues as long as the water in the material comes to the surface so rapidly that the surface remains thoroughly wet, and evaporation proceeds at a constant rate, precisely as from a free water surface. The material tends to assume a temperature corresponding to the wet-bulb temperature of the surrounding air. But the actual temperature is often slightly higher, due to radiation and conduction from dry surfaces adjoining the material. The constant rate period continues until a time is reached when the moisture no longer comes to the surface as fast as it is evaporated. This point is called the *critical moisture content* in the drying process.

As the drying proceeds, a period of *uniform falling rate* is entered. During this period, the surface of the material is gradually drying out, and

the rate of drying falls as the remaining wet surface decreases in area. This period is also known as unsaturated surface drying.

As drying continues, the surface is completely dry and the water from the interior evaporates and comes through the surface as vapor. As the plane of water recedes, the diffusion of the vapor becomes more difficult and hence the period is known as *varying falling rate period*, or sub-surface drying.

Drying ceases when the *equilibrium moisture content* has been reached. The final moisture content of the product depends on the relative humidity of the air in contact with it. Equilibrium is established when the vapor pressure of the moisture in the air and the vapor pressure of the moisture

TABLE 2. FACTORS INFLUENCING DRYING

FACTOR	DRYING PERIOD	
	Constant Rate, Unsaturated Surface	Sub-Surface
Temperature	Increase in temperature increases drying rate	Increase in temperature increases drying rate, because with decreased viscosity, capillary flow is increased.
Humidity	Drying rate increases as humidity is decreased	No effect until equilibrium content is reached; drying then ceases
Air Velocity	Drying rate varies approximately as the 0.6 power of the velocity	No effect
Air Direction	Drying rate increases, the more nearly the air blows perpendicular to surface; for dead air film becomes thinner	No effect
Thickness of Material	Drying rate is not affected by the thickness	Drying rate varies inversely as the square of the thickness

in the material are equal. The equilibrium moisture content varies with the hygroscopic properties of the material, (see table of Regain of Hygroscopic Materials, Chapter 39).

The drying of a slab of whiting is shown in Fig. 5 and illustrates the principles referred to previously. The factors affecting the variations of drying rates during the periods mentioned are outlined in Table 2.

Omissions in the Cycle

Many solids, such as lumber, are so dry at the beginning of the drying operation that the constant rate period of free surface evaporation does not occur. Frequently the surface of the material is dry enough so that no surface drying can take place, in which case only the final stage of sub-surface drying is involved. In other instances, the critical moisture content of a wet solid is sufficiently low that sub-surface drying starts almost immediately after the conclusion of the constant rate period. Thus the intermediate state of unsaturated surface drying does not occur and the

drying is of the sub-surface type during practically the whole of the falling rate period. With other kinds of material, particularly thin sheets, such as newsprint paper, sub-surface drying may occur at such a low moisture content that it is not encountered in commercial work, the falling rate period being confined solely in practice, to unsaturated surface drying.

GENERAL RULES FOR DRYING

Temperature

The highest temperature possible should be used because of faster drying and smaller requirements for ventilation. The amount of moisture that can be carried by a pound of air increases rapidly with rise in temperature as shown in the humidity chart of Fig. 6. Too high a temperature may cause spoilage of materials; many materials calcine or change their chemical properties if heated too hot; gypsum and glauber salts lose some of the chemically combined water, fall apart, and change their chemical properties. Too high or rapid rise in temperatures in drying lumber or ceramics may create a liquid vapor tension within the material so high that the cells explode, causing permanent injury to the fiber. If too high a temperature is used on some chemicals, they begin to react exothermally; a temperature rise and chemical action from within will burn the materials, *e.g.*, bakelite products, gunpowder, etc. During the constant rate period of drying, the material heats only to the wet-bulb temperature of the surrounding air, consequently high temperatures will not injure the material in this stage.

Humidity

Moisture in the drying air may be very important. Many materials tend to case-harden, dry on the outside, forming a skin which retards the moisture flow from the inside to the surface, or stops it completely, and so increases the drying time very much or causes a change of the physical properties of the material. It is often necessary to add humidity to the air in the initial stage of drying. Lumber case-hardens, cracks, and warps if the outside is dried too fast. Ceramics crack if not heated through before drying commences. Elastic materials warp while others crack if not evenly dried. Many paints case-harden if not dried under high humidity.

On the other hand, in the case of those materials whose physical or chemical properties require that they be dried at relatively low temperatures, high humidity tends to retard drying in the first stage and may even stop it altogether in the final stage. Where drying temperatures below 120 to 140 F are used, the drying rate may be highly dependent on atmospheric humidity conditions. In such instances it is often desirable to dehumidify the air entering the dryer during periods of high atmospheric humidity; where a high degree of uniformity is required, it is often possible to secure complete independence of atmospheric conditions by recirculating the air in a closed system which includes a suitable dehumidifier. For this purpose absorptive dehumidifying systems have the advantage of accomplishing the desired reduction of humidity without appreciably elevating or lowering the dry-bulb temperature of the air;

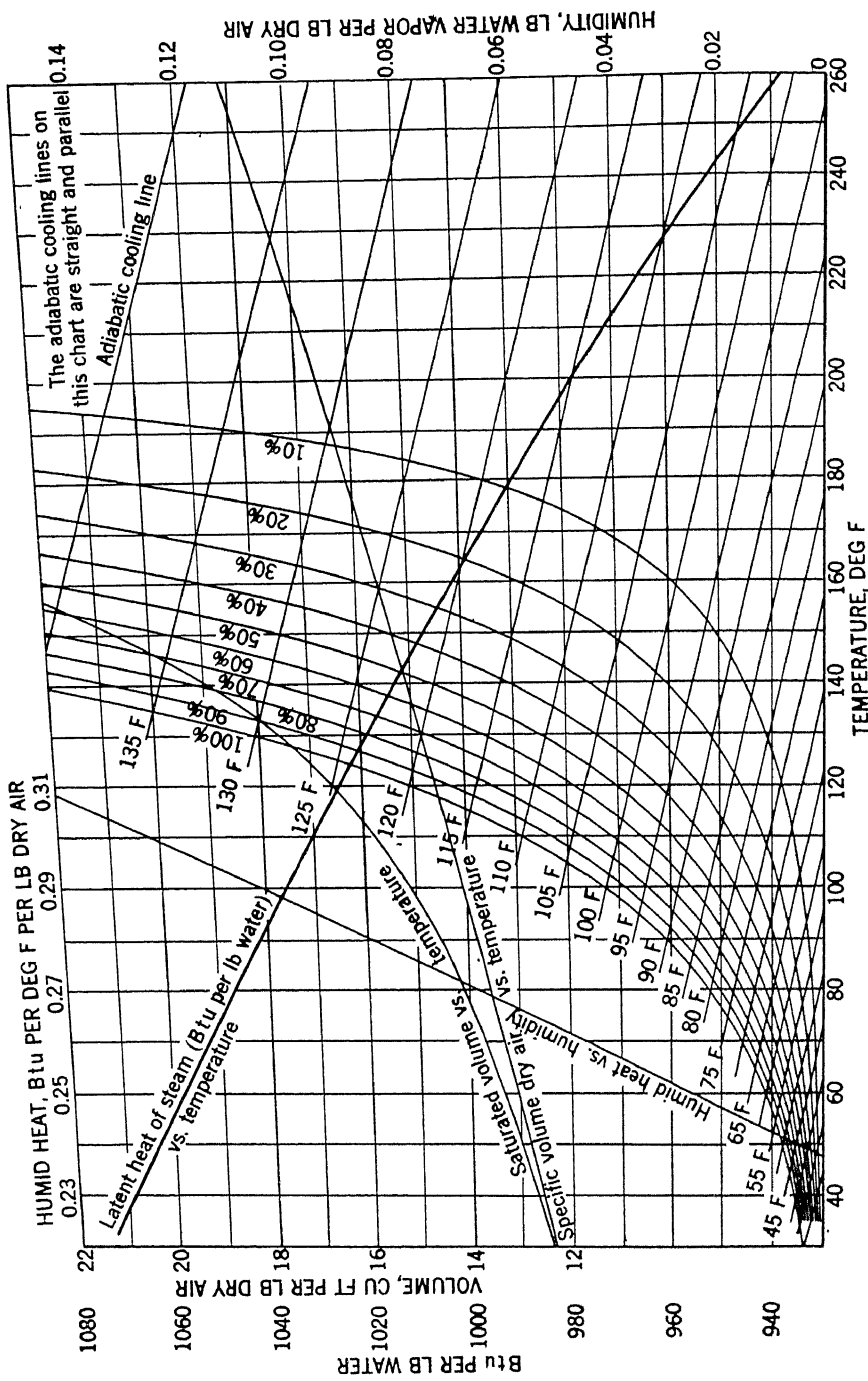


FIG. 6. HUMIDITY CHART

for this reason after-cooling is not required, and reheating is reduced to a minimum. Complete descriptions of such dehumidifying systems are given in Chapter 24 on cooling and dehumidification methods.

Air Circulation

As noted under Mechanism of Drying, air velocity is more important in the first two stages of drying than in the last, and for this reason zone drying in continuous dryers is frequently considered. It permits accurate regulation of temperature, humidity, and velocity in the different zones. High velocity results in more rapid drying, more even distribution of temperature and consequently more even drying in the first period. Too high a velocity may be detrimental because of excessive power needed for creating it, or because the material may blow away if it is light and fluffy. In the drying of paints, varnishes, and enamels, high velocity or improper distribution of the air even with the use of filters, may cause dust already in the dryer to be blown against the material, ruining the finish.

DRYER CALCULATIONS

The fundamental calculations for the design and performance of dryers are based on the thermodynamics of air and water mixtures treated in Chapter 1, and the fundamentals of heat transfer treated in Chapter 3. For the humidity calculations a high-temperature psychrometric chart is given in Fig. 6. In addition to the fundamental heat transfer calculations of radiation, conduction and convection, the heat losses through the walls of the dryer will be computed by the methods illustrated in Chapter 4 and Chapter 43. Additional data on radiation calculations are given in Chapter 45.

Where products of combustion are used directly in a dryer, a knowledge of the properties of fuels and combustion products is important. Data on fuels and combustion are given in Chapter 8. For determining the heat available in products of combustion, a specific heat of 0.25 Btu per pound per degree Fahrenheit may be used.

The calculations for drying during the constant-rate period are different from those applying to the falling-rate period.

Constant-Rate Period

The rate of drying by air passing over a wet surface is directly proportional to the vapor pressure difference, and also proportional to the

TABLE 3. CRITICAL MOISTURE CONTENT FOR VARIOUS MATERIALS^a

MATERIAL	CRITICAL MOISTURE CONTENT, PER CENT
Sand.	3 to 20
Clay; soil; pigments.	5 to 40
Paper, book or coated.	30 to 40
Paper, newsprint.	60 to 70
Paper pulp and pulp-boards (wallboard).	75 to 150
Leather (heavy).	90 to 120

^aThe critical moisture content is expressed as weight of water in per cent of weight of dry material.

0.8 power of the air velocity. For practical calculations the wet surface is assumed to attain the wet-bulb temperature of the air passing over it, and evaporation takes place at constant rate under equilibrium conditions. The equation may then be expressed in three forms:

$$R = C' A V^{0.8} (\Delta P) \quad (1)$$

$$R = C' A V^{0.8} (\Delta H) \quad (2)$$

$$R = C'' A V^{0.8} (\Delta T) \quad (3)$$

where

- R = rate of drying during constant-rate period, pounds of moisture per hour.
 A = area of bed or material in contact with air, square feet.
 V = air velocity over material, feet per minute.
 ΔP = difference between vapor pressure at wet-bulb (surface) temperature and at dew-point of air.
 ΔH = difference between humidity ratio of saturated air, at the surface temperature, and the actual humidity ratio of the air stream, pounds of water per pound of dry air.
 ΔT = difference between dry-bulb and wet-bulb temperatures of air, i.e., the wet-bulb depression.

C, C', C'' = proportionality constants (for numerical values consult references).

These equations are useful mainly for computing the effects of changes in operating conditions, such as changes in air velocity, air temperature, humidity and surface area. The equations assume that the material is in equilibrium at the wet-bulb temperature of the air. If equilibrium has not been reached, or if heat is being added to the charge by radiation or conduction, such conditions must be taken into account. For large tray dryers or continuous surfaces, the logarithmic mean difference should be substituted for the simple difference in ΔP , ΔH and ΔT .

When the constant of proportionality is known for a given set of conditions, Equations 1, 2 or 3 may be applied for basic design, as illustrated in Example 1.

Example 1. Compute the rate of drying of a granular material initially 35 per cent moisture (dry basis), if the material is spread in trays and is to be dried by blowing air horizontally over the surface at 1000 fpm. The air is 140 F dry-bulb, 90 F wet-bulb. Density of the dry material is 85 lb per cubic foot, and the drying constant C'' , in Equation 3, has been found to be about 1/25,000. Find the size of dryer for a capacity of one ton per hour (dry basis), and the time required for drying each batch from 35 to 10 per cent moisture content, if the material is spread in trays, in a layer one inch thick. (The critical moisture content of the material is below 10 per cent, hence the drying is at constant rate.)

Solution: Assume that the surface of the material attains the wet-bulb temperature of the air, then $\Delta T = 140 - 90 = 50$ F. The rate of drying by Equation 3 is:

$$R = C'' A V^{0.8} \Delta T = \frac{1000^{0.8} \times 50}{25,000} = 0.50 \text{ lb of water per hour per square foot of surface.}$$

The total water evaporated per square foot of surface is:

$$W = \frac{85}{12} (0.35 - 0.10) = 1.77 \text{ lb (per batch).}$$

Then the time required per batch is:

$$T = \frac{1.77}{0.50} = 3.54 \text{ hr.}$$

The size of dryer required to dry the material at the rate of one ton of dried material per operating hour will be:

$$A = \frac{2000 \times 3.54}{85/12} = 1000 \text{ sq ft, total area of trays.}$$

Falling-Rate Period

The *critical moisture content* marks the end of the constant rate period and the beginning of the falling-rate period. This falling rate may be due to the fact that the surface is no longer completely wetted, or it may result from a condition in which the moisture cannot reach the surface as fast as it can be evaporated. When this high resistance to capillary flow and diffusion is the governing factor in the drying process, the time of drying increases rapidly with the thickness of the material. During constant-rate drying the time required is directly proportional to the thickness of the bed (see Example 1), while the time required for drying during the falling-rate period is often proportional to the square of the thickness of the material.

Actual calculations of drying during the falling-rate period are not highly satisfactory because of the number of variables. It has been demonstrated empirically that the rate of drying is approximately proportional to the free water content of the material.

An approximate value of the critical moisture content which marks the beginning of the falling-rate period may be obtained from Table 3.

DESIGN

In all drying problems, data regarding temperatures, time, and humidity must be obtained by experiment or previous experience. Experiments are best performed at the temperatures, humidities, and velocities to be actually used in the full sized dryer, and with full size samples.

The following nomenclature and explanation of terms will be used in the discussion of design calculations:

- H = humidity ratio of air, pounds of water vapor per pound of dry air.
- G = pounds of dry air supplied to the dryer per unit of time.
- S = pounds of stock dried per unit of time in a continuous dryer.
- S^1 = pounds of stock charged per batch to a discontinuous dryer.
- Θ = time.
- Q = total heat supplied to the dryer.
- t = air temperature.
- t^1 = stock temperature.
- t^{11} = average stock temperature over short time interval, in a batch dryer.
- t_w = wet-bulb temperature.
- s^1 = specific heat of the stock.
- B = total radiation and conduction losses per unit time.
- w = pounds of water per pound of dry stock.
- r = heat of evaporation of water.
- s = humid heat of air, *i.e.*, heat necessary to raise 1 lb of dry air + H lb of steam 1 F.

Subscript (1) designates conditions at the point where the material in question (air or stock) enters and (2) where it leaves the dryer.

Air dryers may be divided into two classes, those in which *all moisture* evaporated from the stock *leaves the dryer as vapor* in the effluent air, and those in which *part or all* of the moisture *is condensed* from the air *in the drying equipment itself*. In any continuously operating dryer of the first type the relation between moisture content of the stock and quantity of air required for the drying operation is given by the equation:

$$G (H_2 - H_1) = S(w_1 - w_2) \quad (4)$$

In discontinuous dryers, *e.g.*, compartment dryers, the drying operation is given by the equation:

$$G (H_2 - H_1) = S' \frac{dw}{d\Theta} \quad (4a)$$

In the continuous dryer, the heat consumption per unit time is:

$$\frac{Q}{\Theta} = Gs_1(t_2 - t_1) + G(r_2 + t_2 - t'_2) (H_2 - H_1) + S(t'_2 - t'_1) (s' + w_1) + B \quad (5)$$

Equation 5 assumes continuity of operation. For charge or batch operations, the total time of the drying cycle may be broken up into a number of periods, sufficiently short so that over each period average values of t , t' and H may be employed provided the third term of the right hand member of the equation is modified to read:

$$S' (t''_2 - t''_1) (s' - w_1)$$

and in the second term t'_2 be replaced by

$$\frac{t'_1 + t''_2}{2}$$

Theoretically these periods should be very short and the equation integrated. Practically the error introduced by using a small number of long periods and employing average values of the variables over each, rarely introduces serious error. The evaluation of Equation 4a may be approximated in a similar manner.

The first term of the right hand member of Equation 5 represents heat lost as sensible heat in the effluent air. In many drying operations this becomes excessive. Each pound of air supplied should remove the maximum amount of moisture. This is best accomplished by bringing the air into contact with the stock with sufficient intimacy so that the air leaving the dryer is saturated, or nearly so. Counter-current as against parallel flow of air and stock gives rise to optimum operating conditions, resulting in a minimum quantity of air required (G), and a corresponding minimum loss, as sensible heat, in the exit air. Similarly, continuous operation is superior to intermittent operation.

Despite the fact that the sensible heat loss increases with the rise in temperature of the air, the percentage of heat lost from this source decreases, provided the increase in moisture carrying capacity of the air, due to high temperature, is actually utilized. To secure maximum thermal efficiency in drying, a high drying temperature and high saturation of the outlet air is imperative.

Ventilation Phase

The technique of attack of the *ventilation phase* of a drying problem is best made clear by an illustration. Assume that a material containing 40 per cent moisture is to be dried until this quantity of moisture is reduced to 5 per cent by weight. The material will stand an air temperature of 150 F and it is possible to provide sufficiently good contact between the material and the drying air so that the effluent air can be brought up to 50 per cent humidity at 150 F. The dryer is to use room air, the temperature and humidity of which may be assumed to average 70 F and 50 per cent. A counter-current dryer will be employed and the air in this dryer will be kept at a substantially constant temperature of 150 F by heaters thermostatically controlled. The stock enters at 70 F, rises quickly to the wet-bulb temperature of the air, with which it is in contact, and is found experimentally to maintain wet-bulb temperature until the moisture content has fallen to 20 per cent. From this point its

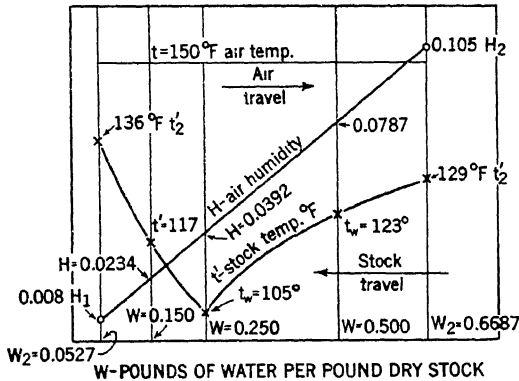


FIG. 7. TEMPERATURE HUMIDITY RELATIONS IN A DRYER

temperature rises progressively as it dries. In this range the difference in temperature between stock and air, divided by the wet-bulb depression, may be assumed proportional to the moisture content.

The moisture content of the entering stock, in the units here employed, is:

$$w_1 = \frac{40 \text{ per cent water}}{60 \text{ per cent dry stock}} = 0.6667; w_2 = \frac{5 \text{ per cent water}}{95 \text{ per cent dry stock}} = 0.0527$$

$w_1 - w_2 = \Delta w = 0.614$ lb water evaporated per pound of dry stock. Since the air leaving the dryer is 50 per cent saturated at 150 F from Fig. 6, $H_2 = 0.105$. Similarly, $H_1 = 0.008$, corresponding to 50 per cent humidity at 70 F. Consequently $H_2 - H_1 = \Delta H = 0.097$ lb water evaporated per pound dry air.

An analysis of Equation 4 shows that (H) is linear in w . Hence, one can construct on Fig. 7, the line marked (H) being drawn connecting the initial and final points just computed.

Since the air leaving the dryer has a temperature of 150 F and a humidity of 0.105, Fig. 6 shows that its wet-bulb temperature is 129 F. This is plotted at the right hand side of Fig. 7. Since the stock maintains

a wet-bulb temperature down to 20 per cent moisture, where $w = 0.25$, the corresponding humidity can be computed by the use of Equation 4 or by reading directly from the diagram, the value being 0.0392. Fig. 6 shows that the corresponding wet-bulb temperature is 105 F. Any intermediate point on the wet-bulb temperature curve can be calculated similarly. The points for $w = 0.5$ are shown in Fig. 7.

Below the point, $w = 0.25$, the temperature of the stock begins to rise appreciably above the wet-bulb temperature. Its temperature at any given point in this range, for example at $w = 0.15$, may be computed as follows: At this point, $H = 0.0234$ (from Equation 4) and from Fig. 6, $t_w = 95$ F. Hence the wet-bulb depression, $t - t_w = 150 - 95 = 55$ F. The assumption made regarding the relation between stock temperature and moisture content in this range may be formulated:

$$\frac{\Delta t'}{t - t_w} = \frac{w}{0.25}$$

At the point $w = 0.15$, $\Delta t' = 33$ F, $t' = 117$ F. The temperature of the stock leaving the dryer, similarly computed, is 136 F.

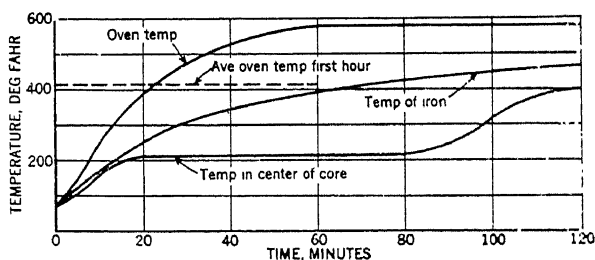


FIG. 8. CORE DRYING TIME TEMPERATURE RELATIONS

Fig. 7 thus computed gives in graphical form the information as to the temperature humidity relationships in the dryer. The air requirements can be computed by Equation 4. Thus, per 100 lb of dry stock, it is necessary to supply 633 lb of dry air. Furthermore, since from Fig. 6 it is seen that the volume of 50 per cent saturated air at 70 F, is 13.55 cu ft per pound; 8580 cu ft of room air must be supplied per 100 lb dry stock. Similarly, since the volume of 50 per cent saturated air at 150 F is 18.0 cu ft per pound, the volume of hot wet air discharged from the dryer is 11,400 cu ft per 100 lb of dry stock. Finally, the heat necessary to supply to the dryer, as a whole, or to any section of it, may be computed from Equation 5.

High Temperature Dryer

In the design of a high temperature dryer unit a method of approach to the necessary calculations involved is outlined as follows:

Example 2. Cores 4 and 5 in. thick are to be dried by heating to a temperature at 400 F. An intermittent type box oven is to be used, size 12 x 14 x 10 ft with 856 sq ft surface having an average heat transfer of 0.3 Btu per square foot per degree per hour. Drying time as determined by test is 2 hr (Fig. 8). Cores weighing 6 tons, and 15-ton steel plates, trucks etc. are delivered to the dryer at 70 F. The oven is heated by an

CHAPTER 41. DRYING SYSTEMS

external heater; the products of combustion and 66½ per cent recirculated air will be delivered to the oven at 825 F. Fuel oil of 19,980 Btu gross and 18,830 Btu per pound net heating value, weighing 6.75 lb per gallon and having 15 lb product per pound fuel for perfect combustion. Cores consist of 91 per cent sand, 3 per cent oil binder, and 6 per cent water.

Solution. Heat required per ton of cores:

	Lb Material	× Temp. Rise	× Sp. Ht.	= Btu
Sand.....	0.91 × 2,000	× (400 - 70)	× 0.2	= 120,120
Binder.....	0.03 × 2,000	× (400 - 70)	× 0.4	= 7,920
Water heating.....	0.06 × 2,000	× (212 - 70)	× 1.0	= 17,040
Water evaporation.....	0.06 × 2,000	× 970 (Fig. 6)		= 116,520
Water superheating (approx. 50 per cent reaches 575 F)	$= 0.5 \times 0.06 \times 2,000 \times (575 - 212) \times 0.45$			= 9,800
Total Heat.....				271,400 Btu
Heat in 1 lb fuel oil	=	18,830 Btu		
Heater Loss (10 per cent)	= 1883			
Duct Loss (5 per cent)	= 942	2,825 Btu		
		16,005 Btu available to heat oven.		

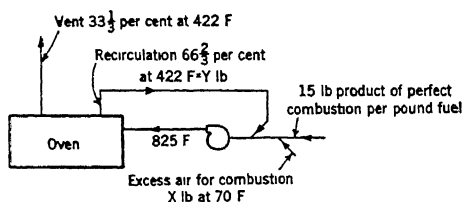


FIG. 9. CORE DRYING DIAGRAM OF COMBUSTION PRODUCTS AND AIR

Heat content of gases in 1 lb fuel oil at 825 F is 205 Btu

$$15 \text{ lb} \times 205 = 3,075 \text{ Btu sensible heat in products of perfect combustion.}$$

$$12,930 \text{ Btu to heat air } X \text{ and } Y \text{ (Fig. 9).}$$

$$Y (S_{825} - S_{422}) + X (S_{825} - S_{70}) = 12,930 \quad (6)$$

$$Y = 2 (X + 15) \text{ for 66.7 per cent recirculation}$$

where

S = heat content of air at temperature noted taken from Fig. 6.

(Recirculation and exhaust contains water vapor, products of combustion, and a greater portion of air. Heat capacities of all vary so little that they have all been assumed to be air).

$$S_{825} - S_{422} = 190 - 91 = 99$$

$$S_{825} - S_{70} = 190 - 8.6 = 181.4$$

Substituting values of Y , H , etc. in Equation 6,

$$(2X + 30) 99 + 181.4 X = 12,930$$

$$X = 26.3 \text{ lb excess air.}$$

$$Y = 82.6 \text{ lb recirculating air.}$$

Total = 26.3 + 82.6 + 15 = 123.9 lb air and products of combustion circulated per pound fuel burned.

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Heat in air exhausted from oven at 422 F per pound fuel burned = $0.333 \times 123.9 \times (S_{422} - S_{70}) = 41.3 (91 - 8.6) = 3,400$ Btu.

Btu available for heating material = $16,005 - 3,400 = 12,605$ Btu per pound fuel.

Fuel used in first hour = $2,180,470 \div 12,605 = 173$ lb = 25.6 gal.

During the second hour the heater capacity will be much greater than required. If an automatic oven temperature control operates on the oil supply, the delivery temperature of the air entering the oven and the quantity of oil burned will decrease, the air supply being constant.

Heat in air exhausted = $41.3 (S_{575} - S_{70}) = 41.3 (127 - 8.6) = 4,880$ Btu per pound fuel.

Heat available for heating material = $16,005 - 4,880 = 11,125$ Btu.

Fuel used in second hour = $1,072,008 \div 11,125 = 96.5$ lb oil = 14.3 gal.

Total oil used per load = $25.6 + 14.3 = 39.9$ gal.

HEATING LOAD FIRST HOUR

	HEATED TO		Btu
Sand.....	212 F	$\frac{142}{330} \times 120,120$	= 51,688
Binder ^a	212 F	$\frac{142}{330} \times 7,920$	= 3,408
Water.....	212 F		= 17,040
Evaporation.....	66.7%	$0.667 \times 116,520$	= 77,680
Superheat.....	66.7%	$0.667 \times 9,800$	= 6,530
Total Per Ton.....			156,346
For 6 ton.....		$6 \times 156,346$	= 938,076
Steel plates.....	390 F	$320 \times 30,000 \times 0.12$	= 1,152,000
Radiation ^b	422 F Avg	$352 \times 856 \times 0.30$	= 90,394
Total.....			2,180,470

HEATING LOAD SECOND HOUR

Sand.....	400 F	$\frac{188}{330} \times 120,120$	= 68,432
Binder ^a	400 F	$\frac{188}{330} \times 7,920$	= 4,512
Water.....			
Evaporation.....	33.3%	$0.333 \times 116,520$	= 38,840
Superheat.....	33.3%	$0.333 \times 9,800$	= 3,270
Total Per Ton.....			115,054
For 6 ton.....		$6 \times 115,054$	= 690,324
Steel plates.....	460	$70 \times 30,000 \times 0.12$	= 252,000
Radiation ^b	575	$505 \times 856 \times 0.30$	= 129,684
Total.....			1,072,008

^aBinder oxidizes and liberates heat, which is neglected in this calculation.

^bAverage value of coefficient is less than 0.3 because oven is not up to 575 F. This is neglected. 422 F is arrived at by taking area under curve as compared to area under 575 F ordinate.

ESTIMATING METHODS

Values based on practical experience are available for rough estimating of drying problems. The temperature will drop approximately 8.5 F per grain of water evaporated per cubic foot of air (measured at 70 F) or approximately 0.62 F per pound of air at any temperature. Air will drop 55 F per cubic foot for each Btu extracted. Generally air will absorb from 2 grains to 5 grains per cubic foot of air in one passage through an air dryer, depending on the temperature and the degree of contact with the material. The amount of steam required to evaporate a pound of water will vary from 1.5 lb to a more usual figure of from 2.5 to 3 lb of steam per pound of water evaporated.

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Chapter 42

NATURAL VENTILATION

Wind Forces, Stack Effect, Openings, Windows, Doors, Skylights, Roof Ventilators, Stacks, Principles of Control, General Rules, Measurements, Dairy Barn Ventilation, Garage Ventilation

VENTILATION by natural forces, finds application in industrial plants, public buildings, schools, dwellings, garages, and in farm buildings.

The natural forces available for moving air into, through and out of buildings are: (a) wind forces, and (b) the difference in temperature between the air inside and outside a building. The air movement may be caused by either of these forces acting alone or by a combination of the two, depending upon atmospheric conditions, building design and location. The ventilating results obtained will vary, from time to time, due to variation in the velocity and direction of the wind and the heat generated in the building. The arrangement, location, and control of the ventilating openings should be such that the two forces act cooperatively rather than in opposition.

WIND FORCES

In considering the use of natural wind forces for producing ventilation, account must be taken of: (1) average wind velocity, (2) prevailing wind direction, (3) seasonal and daily variations in velocity and direction, and (4) local wind interference by nearby buildings, hills or other obstructions of similar nature.

Values are given in Table 1, Chapter 7 for the average summer wind velocities and the prevailing wind directions in various localities throughout the United States, while Table 2, Chapter 6, lists similar values for the winter. In almost all localities the summer wind velocities are lower than those in the winter, and in about two-thirds of the localities the prevailing direction is different during the summer and winter. While the tables give no average velocities below 5 mph, there will be times when the velocity is lower, even in localities where the seasonal average is considerably above 5 mph. There are relatively few places where the velocity falls below one half of the average for many hours per month. Consequently, if the natural ventilating system is designed for wind velocities of one-half of the average seasonal velocity, it should prove satisfactory in almost every case.

Equation 1 may be used for calculating the quantity of air forced through ventilation openings by the wind, or for determining the proper size of such openings to produce given results:

$$Q = EA V \quad (1)$$

where

Q = air flow, cubic feet per minute.

A = free area of inlet openings, square feet.

V = wind velocity, feet per minute, = miles per hour $\times 88$.

E = effectiveness of openings. (E should be taken at 0.50 to 0.60 for perpendicular winds and 0.25 to 0.35 for diagonal winds¹.)

The accuracy of the results obtained by the use of Equation 1 depends upon the placing of the openings, as the formula assumes that ventilating openings have a flow coefficient slightly greater than that of a square-edged orifice. If the openings are not advantageously placed with respect to the wind, the flow per unit area of the openings will be less and, if unusually well placed, the flow will be slightly more than that given by the formula. Inlets should be placed to face directly into the prevailing wind, while outlets should be placed in one of the five places listed:

1. On the side of the building directly opposite the direction of the prevailing wind.
2. On the roof in the low pressure area caused by the jump of the wind (see Fig. 1).
3. On the sides adjacent to the windward face where low pressure areas occur.
4. In a monitor on the side opposite from the wind.
5. In roof ventilators or stacks.

TEMPERATURE DIFFERENCE FORCES²

The stack effect produced within a building when the outdoor temperature is lower is due to the difference in weight of the warm column of air within the building and the cooler air outside. The flow due to stack effect is proportional to the square root of the draft head, or approximately:

$$Q = 9.4 A \sqrt{H (t - t_o)} \quad (2)$$

where

Q = air flow, cubic feet per minute.

A = free area of inlets or outlets (assumed equal), square feet.

H = height from inlets to outlets, feet.

t = average temperature of indoor air in height H , degrees Fahrenheit.

t_o = temperature of outdoor air, degrees Fahrenheit.

9.4 = constant of proportionality, including a value of 65 per cent for effectiveness of openings. This should be reduced to 50 per cent (constant = 7.2) if conditions are not favorable.

HEAT REMOVAL

In problems of heat removal, knowing the amount of heat to be removed and having selected a desirable temperature difference, the amount

¹Predetermining Airation of Industrial Buildings, by W. C. Randall and E. W. Conover (A.S.H.V.E. TRANSACTIONS, Vol. 37, 1931, p. 605).

²Neutral Zone in Ventilation, by J. E. Emswiler (A.S.H.V.E. TRANSACTIONS, Vol. 32, 1926, p. 59).

of air to be passed through the building per minute to maintain this temperature difference can be determined by means of Equation 3.

$$H = 0.0175 Q (t - t_o) \quad (3)$$

where

H = heat removed, Btu per minute.

Q = air flow, cubic feet per minute.

$t - t_o$ = inside-outside temperature difference, degrees Fahrenheit.

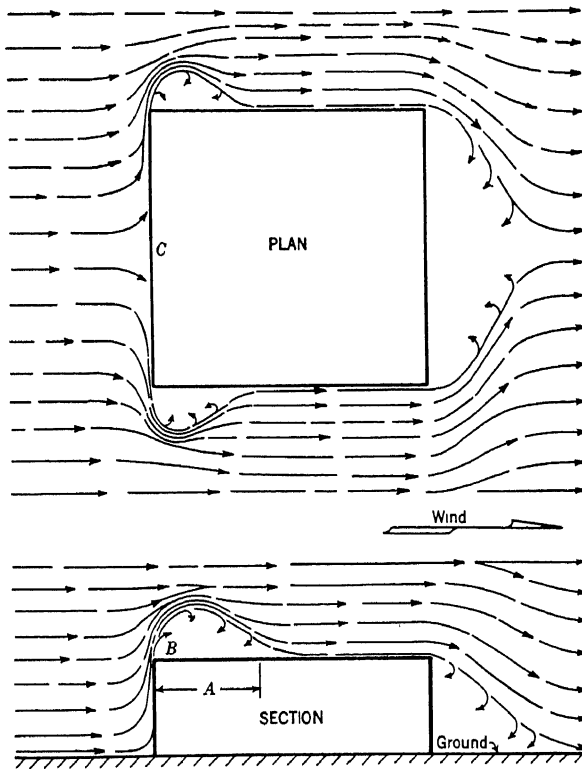


FIG. 1. THE JUMP OF WIND FROM WINDWARD FACE OF BUILDING. (A—LENGTH OF SUCTION AREA; B—POINT OF MAXIMUM INTENSITY OF SUCTION; C—POINT OF MAXIMUM PRESSURE)

EFFECT OF UNEQUAL OPENINGS

The largest flow per unit area of openings is obtained when inlets and outlets are equal, and the equations given previously are based on this condition. Increasing outlets over inlets, or vice-versa, will increase the air flow, but not in proportion to the added area. When solving problems having an unequal distribution of openings, use the smaller area, either inlet or outlet, in the equations and add the increase as determined from Fig. 2.

COMBINED FORCES OF WIND AND TEMPERATURE

Equations for determining the air flow due to temperature difference and wind have already been given. It must be remembered that when both forces are acting together, even without interference, the resulting air flow is not equal to the sum of the two estimated quantities. The flow through any opening is proportional to the square root of the sum of the forces acting on that opening.

When the two forces are about equal in intensity and the ventilating openings are operated so as to coordinate them, the total air flow through the building is about 10 per cent greater than that produced by either force acting independently under conditions ideal to that force. This

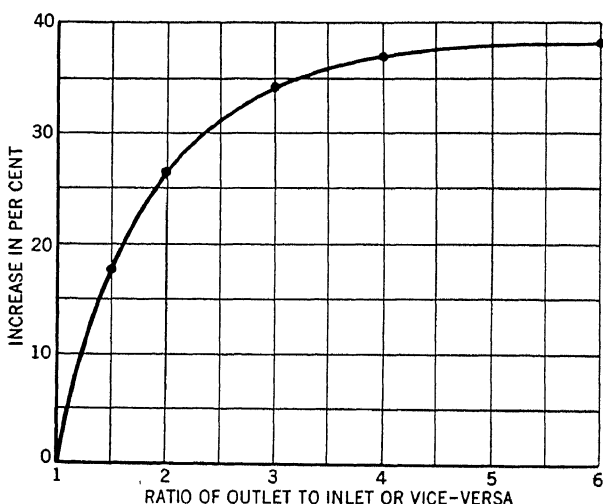


FIG. 2. INCREASE IN FLOW CAUSED BY EXCESS OF ONE OPENING OVER ANOTHER

percentage decreases rapidly as one force increases over the other and the larger force will predominate.

The wind velocity and direction, the outdoor temperature, or the indoor distribution, cannot be predicted with certainty, and refinement in calculations is not justified; consequently, a simplified method can be used. This may be done by using the equations and calculating the flows produced by each force separately under conditions of openings best suited for coordination of the forces. Then by determining as a percentage, the ratio of the flow produced by temperature difference to the sum of the two flows, the actual flow due to the combined forces can be approximated from Fig. 3.

Example 1. Assume a drop forge shop, 200 ft long, 100 ft wide, and 30 ft high. The cubical content is 600,000 cu ft, and the height of the air outlet over that of the inlet is 30 ft. Oil fuel of 18,000 Btu per pound is used in this shop at the rate of 15 gal per hour (7.75 lb per gal). Desired summer temperature difference is 10 F and the prevailing wind is 8 mph perpendicular to the long dimension. What is the necessary area for the inlets and outlets, and what is the rate of air flow through the building?

Solution for Temperature Difference Only. The heat $H = \frac{15 \times 7.75 \times 18,000}{60} = 34,875$ Btu per minute.

By Equation 3, the air flow required to remove this heat with an average temperature difference of 10 F is:

$$Q = \frac{H}{0.0175 (t - t_o)} = \frac{34,875}{0.0175 \times 10} = 199,286 \text{ cfm.}$$

This is equal to about 20 air changes per hour. From Equation 2 the inlet (or outlet) opening area should be:

$$A = \frac{Q}{9.4 \sqrt{H (t - t_o)}} = \frac{199,286}{9.4 \sqrt{30 \times 10}} = 1224 \text{ sq ft.}$$

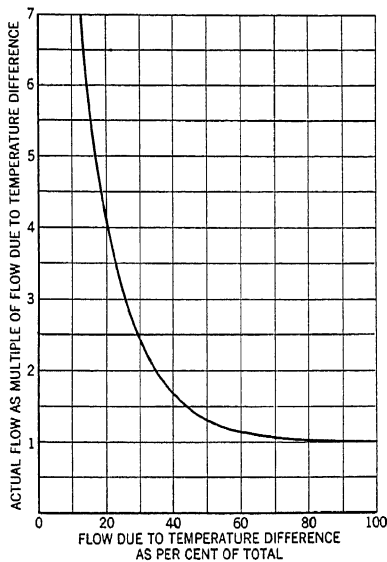


FIG. 3. DETERMINATION OF FLOW CAUSED BY COMBINED FORCES OF WIND AND TEMPERATURE DIFFERENCE

The flow per square foot of inlet or outlet would be $199,286 \div 1224 = 163$ cfm with all windows open.

Solution for Wind Only. With 1,224 sq ft of inlet openings distributed around the sidewalls, there would be about 410 sq ft in each long side and 202 sq ft in each end. The outlet area will be equally distributed on the two sides of the monitor, or 612 sq ft on each side. With the wind perpendicular to the long side, there will be 410 sq ft of opening in its path for inflow and 612 in the lee side of the monitor for outflow with the windward side closed. The air flow, as calculated by Equation 1, will be:

$$Q = 0.60 \times 410 \times 704 = 173,200 \text{ cfm.}$$

This gives 17.3 air changes per hour, which should be more than ample when there is no heat to be removed.

Solution for Combined Forces. Since the windward side of the monitor is closed when the wind is blowing, the flow due to temperature difference must be calculated for this condition, using Fig. 2. This chart shows that when inlets are twice the size of the outlets, in this case 1,224 sq ft in the sidewalls and 612 sq ft in the monitor, the flow will be increased 26.5 per cent over that produced by equal openings. Using the smaller

opening and the flow per square foot obtained previously, the calculated amount for this condition will be:

$$612 \times 163 \times 1.265 = 126,200 \text{ cfm.}$$

Adding the two computed flows:

Temperature Difference	= 126,200	= 42 per cent.
Wind	= 173,200	= 58 per cent.
Total	299,400	= 100 per cent.

From Fig. 3, it is determined that when the flow, due to temperature difference, is 42 per cent of the total, the actual flow, due to the combined forces, will be about 1.6 times that calculated for temperature difference alone, or 201,920 cfm.

The original flow, due to temperature difference alone, was 199,286 cfm with all openings in use. The effect of the wind is to increase this to 201,920 cfm even though half of the outlets are closed.

A factor of judgment is necessary in the location of the openings in a building, especially those in the roof, where heat, smoke and fumes are to be removed. Usually windward monitor openings should be closed, but if the wind is low enough for the temperature head to overcome it, all windows may be opened.

TYPES OF OPENINGS

Types of openings may be classified as: (1) windows, doors, monitor openings and skylights, (2) roof ventilators, (3) stacks connecting to registers, and (4) specially designed inlet or outlet openings.

Windows, Doors and Skylights

Windows have the advantage of transmitting light, as well as providing ventilating area when open. Their movable parts are arranged to open in various ways; they may open by sliding either vertically or horizontally, by tilting on horizontal pivots at or near the center, or by swinging on pivots at the top, bottom or side. Regardless of their design, the air flow per square foot of opening will be the same under the same conditions. The type of pivoting should receive consideration from the standpoint of weather protection, and certain types may be advantageous in controlling the distribution of incoming air. Deflectors are sometimes used for the same purpose, and these devices should be considered a part of the ventilation system.

Roof Ventilators

The function of a roof ventilator is to provide a storm and weather proof air outlet. These are actuated by the same forces of wind and temperature head, which create flow through other types of openings. The capacity of a ventilator depends upon four things: (1) its location on the roof, (2) the resistance it and the duct work offers to air flow, (3) the height of draft, and (4) the efficiency of the ventilator in utilizing the kinetic energy of the wind for inducing flow by centrifugal or ejector action.

For maximum flow induction, a ventilator should be located on that part of the roof where it will receive the full wind without interference. If ventilators are installed within the suction region created by the wind

passing over the building, or in a light court, or on a low building between two high buildings, their performance will be the same there as for any other type of opening of the same area. Their normal ejector action, if any, will be of no value in such a location.

The base of the ventilator should be of a taper-cone design to produce the effect of a bell-mouth nozzle whose coefficient of flow is considerably higher than that of a square-entrance orifice. If a grille is provided at the base, additional resistance is introduced, and it should be increased in size accordingly.

Air inlet openings located at lower levels in the building should be at least equal to, and preferably larger than the combined throat areas of all roof ventilators. The air discharged by a roof ventilator depends on wind velocity and temperature difference, and, in general, their performance will be the same as any monitor opening located in the same place, but due to the four capacity factors already mentioned, no simple formula can be devised for expressing ventilator capacity.

Roof ventilators may be classified as stationary, pivoting or oscillating, and rotating. Generally, these have a round throat, but the continuous-ridge ventilator, or so-called heat valve, would fall in the stationary classification. When selecting roof ventilators, some attention should be given to ruggedness of construction, storm proofing features, dampers and damper operating mechanisms, possibility of noise, original cost and maintenance.

Natural ventilation units may be used to supplement power-driven supply fans, and under favorable weather conditions it may be possible to stop the power-driven units.

Controls

Gravity ventilators may have dampers controlled by (1) hand, (2) thermostat, and (3) wind velocity, in combination with a fan. The thermostat station may be located anywhere in the building, or it may be located within the ventilator itself. The purpose of wind velocity control is to obtain a definite volume of exhaust regardless of the natural forces, the fan motor being energized when the natural exhaust capacity falls below a certain minimum, and again shut off when the wind velocity rises to the point where this minimum volume can be supplied by natural forces.

Stacks

Stacks or vertical flues are really chimneys and utilize both the inductive effect of the wind and the force of temperature difference. Like the roof ventilator, the stack outlet should be located so that the wind may act upon it from any direction. With little or no wind, chimney effect depends on temperature difference to produce a removal of air from the rooms where the inlet openings are located.

GENERAL RULES

A few of the important requirements in addition to those already outlined are:

1. Inlet openings in the building should be well distributed, and should be located on

the windward side near the bottom, while outlet openings are located on the leeward side near the top. Outside air will then be supplied to the zone to be ventilated.

2. Inlet openings should not be obstructed by buildings, trees, sign boards, etc., outside nor by partitions inside.

3. Greatest flow per square foot of total opening is obtained by using inlet and outlet openings of nearly equal areas.

4. In the design of window ventilated buildings, where the direction of the wind is quite constant and dependable, the orientation of the building together with amount and grouping of ventilation openings can be readily arranged to take full advantage of the force of the wind. Where the wind's direction is quite variable, the openings should be arranged in sidewalls and monitors so that, as far as possible, there will be approximately equal areas on all sides. Thus, no matter what the wind's direction, there will always be some openings directly exposed to the pressure force and others to a suction force, and effective movement through the building will be assured.

5. Direct short circuits between openings on two sides at a high level may clear the air at that level without producing any appreciable ventilation at the level of occupancy.

6. In order that temperature difference may produce a motive force, there must be vertical distance between openings. That is, if there are a number of openings available in a building, but all are at the same level, there will be no motive head produced by temperature difference, no matter how great that difference might be.

7. In order that the force of temperature difference may operate to maximum advantage, the vertical distance between inlet and outlet openings should be as great as possible. Openings in the vicinity of the neutral zone are less effective for ventilation.

8. In the use of monitors, windows on the windward side should usually be kept closed, since, if they are open, the inflow tendency of the wind counteracts the outflow tendency of temperature difference. Openings on the leeward side of the monitor result in cooperation of wind and temperature difference.

9. In an industrial building where furnaces that give off heat and fumes are to be installed, it is better to locate them in the end of the building exposed to the prevailing wind. The strong suction effect of the wind at the roof near the windward end will then cooperate with temperature difference, to provide for the most active and satisfactory removal of the heat and gas laden air.

10. In case it is impossible to locate furnaces in the windward end, that part of the building in which they are to be located should be built higher than the rest, so that the wind, in splashing therefrom will create a suction. The additional height also increases the effect of temperature difference to cooperate with the wind.

11. The intensity of suction or the vacuum produced by the jump of the wind is greatest just back of the building face. The area of suction does not vary with the wind velocity, but the flow due to suction is directly proportional to wind velocity.

12. Openings much larger than the calculated areas are sometimes desirable, especially when changes in occupancy are possible, or to provide for extremely hot days. In the former case, free openings should be located at the level of occupancy for psychological reasons.

13. In single story industrial buildings, particularly those covering large areas, natural ventilation must be accomplished by taking air in and out of the roof openings. Openings in the pressure zones can be used for inflow and openings in the suction zone, or openings in zones of less pressure, can be used for outflow. The ventilation is accomplished by the manipulation of openings to get air flow through the zones to be ventilated.

DAIRY BARN VENTILATION ³

A successful barn ventilating system is one which continuously supplies the proper amount of air required by the stock, with proper distribution and without drafts, and one which removes the excessive heat, moisture,

³Dairy Barn Ventilation, by F. L. Fairbanks (A.S.H.V.E. TRANSACTIONS, Vol. 31, 1928, p. 181). Cow Barn Ventilation, by Alfred J. Offner (A.S.H.V.E. TRANSACTIONS, Vol. 39, 1933, p. 149). For additional information on this subject refer to *Technical Bulletin, U. S. Department of Agriculture* (1930), by M. A. R. Kelley. Also see *Air Conditioning of Farm Buildings*, by F. L. Fairbanks (*Agricultural Engineering*, November, 1937, p. 485).

and odors, and maintains the air at a proper temperature, relative humidity, and degree of cleanliness.

Barn temperatures below freezing and above 80 F affect milk production. Milk producing stock should be kept in a barn temperature between 45 and 50 F. Dry stock, at reduced feeding, may be kept in a barn 5 to 10 deg higher. Calf barns are generally kept at 60 F, while hospital and maternity barns usually have a temperature of 60 F or somewhat higher.

The heat produced by a cow of an average weight of 1000 lb may be taken as 3000 Btu per hour. The average rate of moisture production by a cow giving 20 lb of milk per day is 15 lb of water per day, or 4375 grains per hour. To set a standard of permissible relative humidity for cow barns is difficult. For 45 F an average relative humidity of 80 per cent is satisfactory, with 85 per cent as a limit.

Where the barn volume is within the limit that can be heated by the stabled animals, the air supply need not be heated. The air should be supplied through or near the ceiling. It is better to have the exhaust openings near the floor as larger volumes of warm air are then held in the barn and there is better temperature control with less likelihood of sudden change in barn temperature.

If a cow weighs 1000 lb and produces 3000 Btu of heat per hour, and if a barn for the cow has 600 cu ft of air space with 130 sq ft of building exposure, one cow will require 2600 to 3550 cu ft per hour of ventilation, depending on the temperature zone in which the barn is located. The permissible heat losses through the structure, based on one cow and depending on the temperature zone, vary between 0.043 and 0.066 Btu per hour per cubic foot of barn space, and 0.197 to 0.305 Btu per hour per square foot of barn exposure.

GARAGE VENTILATION

On account of the hazards resulting from carbon monoxide and other physiologically harmful or combustible gases or vapors in garages, the importance of proper ventilation of these buildings cannot be over-emphasized. During the warm months of the year, garages are usually ventilated adequately because the doors and windows are kept open. As cold weather sets in, more and more of the ventilation openings are closed and consequently on extremely cold days the carbon monoxide concentration runs high.

Many garages can be satisfactorily ventilated by natural means particularly during the mild weather when doors and windows can be kept open. However, the A.S.H.V.E. Code for Heating and Ventilating Garages, adopted in 1929 and revised in 1935, states that natural ventilation may be employed for the ventilation of storage sections where it is practical to maintain open windows or other openings at all times. The code specifies that such openings shall be distributed as uniformly as possible in at least two outside walls, and that the total area of such openings shall be equivalent to at least 5 per cent of the floor area. The code further states that where it is impractical to operate such a system of natural ventilation, a mechanical system shall be used which shall provide for either the supply of 1 cu ft of air per minute from out-of-doors

for each square foot of floor area, or for removing the same amount and discharging it to the outside as a means of flushing the garage.⁴

Research

Research on garage ventilation, undertaken by the A.S.H.V.E. Committee on Research at Washington University, St. Louis, Mo., and at the University of Kansas, Lawrence, Kans., in cooperation with the A.S.H.V.E. Research Laboratory, and at the A.S.H.V.E. Research Laboratory, has resulted in authoritative papers on the subject.

Some of the conclusions from work at the Laboratory are listed in the following statements:

1. Upward ventilation results in a lower concentration of carbon monoxide at the breathing line and a lower temperature above the breathing line than does downward ventilation, for the same rate of carbon monoxide production, air change and the same temperature at the 30-in. level.

2. A lower rate of air change and a smaller heating load are required with upward than with downward ventilation.

3. In the average case upward ventilation results in a lower concentration of carbon monoxide in the occupied portion of a garage than is had with complete mixing of the exhaust gases and the air supplied. However, the variations in concentration from point to point, together with the possible failure of the advantages of upward ventilation to accrue, suggest the basing of garage ventilation on complete mixing and an air change sufficient to dilute the exhaust gases to the allowable concentration of carbon monoxide.

4. The rate of carbon monoxide production by an idling car is shown to vary from 25 to 50 cu ft per hour, with an average rate of 35 cu ft per hour.

5. An air change of 350,000 cu ft per hour per idling car is required to keep the carbon monoxide concentration down to one part in 10,000 parts of air.

⁴Code for Heating and Ventilating Garages (A.S.H.V.E. TRANSACTIONS, Vol. 35, 1929, p. 355), (A.S.H.V.E. Reprint, January, 1935).

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A.S.H.V.E. RESEARCH REPORT No. 967—Carbon Monoxide Distribution in Relation to the Heating and Ventilation of a One-Floor Garage, by F. C. Houghten and Paul McDermott (A.S.H.V.E. TRANSACTIONS, Vol. 39, 1933, p. 395).

Carbon Monoxide Surveys of Two Garages, by A. H. Sluss, E. K. Campbell and Louis M. Farber (A.S.H.V.E. TRANSACTIONS, Vol. 40, 1934, p. 263).

Chapter 43

PIPE AND DUCT HEAT LOSSES

Heat Losses from Bare and Insulated Pipes, Low Temperature Pipe Insulation, Insulation of Pipes to Prevent Freezing, Economical Thickness of Pipe Insulation, Underground Pipe Insulation, Heat Losses from Ducts

THE heat transfer through uninsulated pipes and ducts may be of considerable magnitude if the temperature of the surrounding medium differs appreciably from that of the fluid conveyed. Careful consideration must, therefore, be given to this factor in a properly designed system and adequate insulation provided, if necessary.

HEAT LOSSES FROM BARE PIPES

Heat losses from horizontal bare steel pipes, based on tests at *Mellon Institute* and calculated from the fundamental radiation and convection equations (Chapter 3), are given in Table 1. Heat losses from horizontal copper tubes and pipes with bright, lacquered and tarnished surfaces, are given in Tables 2, 3 and 4¹.

The monetary values of the heat losses given in Tables 1, 2, 3 and 4 may be obtained by means of Fig. 1 for various heating system efficiencies, temperature differences, and calorific values, and costs of coal. This chart, however, is intended for heat losses greater than 2 Btu per linear foot per hour per degree Fahrenheit temperature difference. To solve a problem, select the proper heat loss coefficient from Tables 1, 2, 3 or 4 and locate this value on the upper left-hand margin of the chart. Then draw lines in the order indicated by the dotted lines, the dollar value of the heat loss per 100 linear feet of pipe per 1000 hours being given on the upper right-hand scale. In using the chart, the cost of coal should also include the labor for handling it, boiler room expense, etc.

The area in square feet per linear foot of pipe is given in Table 5 for various standard pipe sizes, and Table 6 for copper tubing, while Table 7 gives the area in square feet of flanges and fittings for various standard pipe sizes. These tables can be used to advantage in estimating the amount of insulating cement required for various equipment.

Very often, when pipes are insulated, flanges and fittings are left bare so as to allow for easy access to the fittings in case of repairs. The fact that a pair of 8-in. standard flanges having an area of 2.41 sq ft would

¹Heat Loss from Copper Piping, by R. H. Heilman (*Heating, Piping and Air Conditioning*, September, 1933, p. 458).

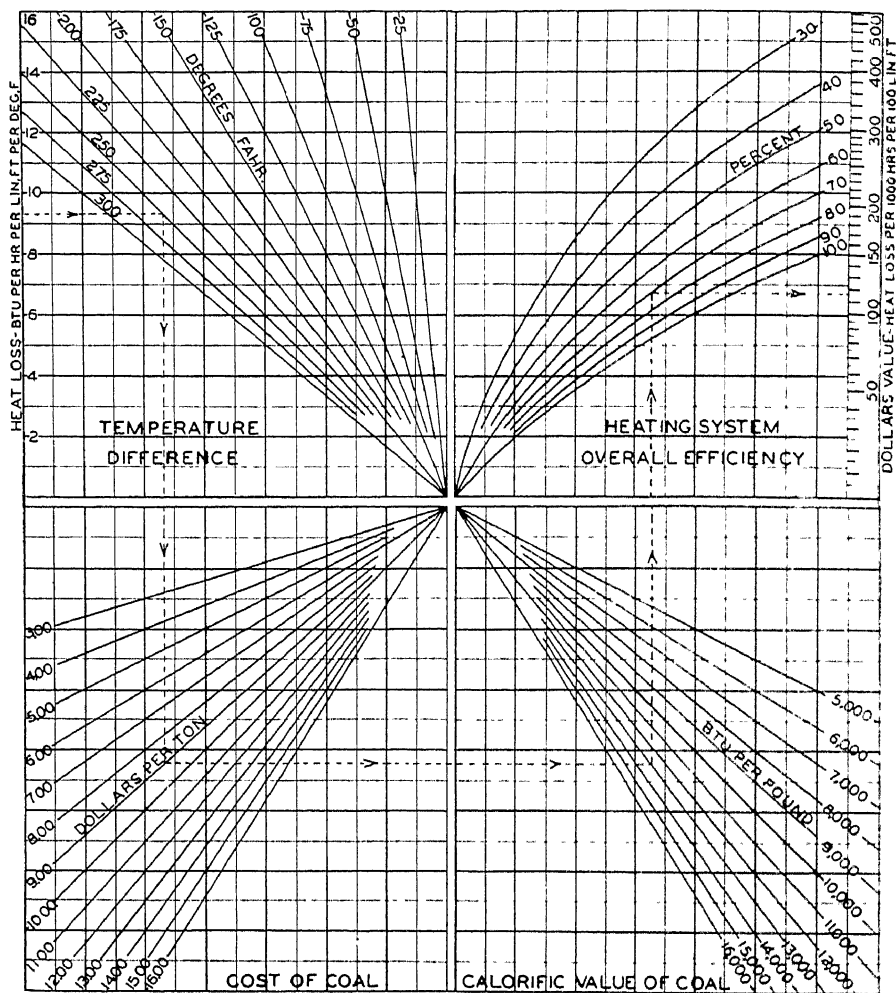


FIG. 1. CHART FOR ESTIMATING DOLLAR VALUE OF HEAT LOSS FROM BARE PIPES. (SEE TABLES 1, 2, 3 AND 4)^a

^aThis chart is based on 100 linear feet per 1000 hours. For fractions or multiples of these factors, multiply by proper percentage.

lose, at 100 lb steam pressure, an amount of heat equivalent to more than a ton of coal per year shows the necessity for insulating such surfaces.

Example 1. Compute the total annual heat loss from 165 ft of 2 in. bare pipe in service 4000 hours per year. The pipe is carrying steam at 10 lb pressure and is exposed to an average air temperature of 70 F.

Solution. The pipe temperature is taken as the steam temperature, which is 239.4 F, obtained by interpolation from Table 8, Chapter 1. The temperature difference between the pipe and air = $239.4 - 70 = 169.4$ F. By interpolation of Table 1 between temperature differences of 157.1 and 227.7 F, the heat loss from a 2 in. pipe at a temperature difference of 169.4 F is found to be 1.624 Btu per hour per linear foot per degree temperature difference. The total annual heat loss from the entire line = $1.624 \times 169.4 \times 165$ (linear feet) \times 4000 (hours) = 181,600 Mb.

CHAPTER 43. PIPE AND DUCT HEAT LOSSES

Example 2. Coal costing \$11.50 per ton and having a calorific value of 13,000 Btu per pound is being burned in the furnace supplying steam to the pipe line given in the previous example. If the system is operating at an overall efficiency of 55 per cent, determine the monetary value of the annual heat loss from the line.

Solution. The cost of heat per 1000 Mb supplied to the system = $1,000,000 \times 11.5$

TABLE 1. HEAT LOSSES FROM HORIZONTAL BARE STEEL PIPES
Expressed in Btu per hour per linear foot per degree Fahrenheit difference in temperature between the pipe and surrounding still air at 70 F

NOMINAL PIPE SIZE (INCHES)	HOT WATER				STEAM		
	120 F	150 F	180 F	210 F	227.1 F (5 Lb)	299.7 F (50 Lb)	337.9 F (100 Lb)
	TEMPERATURE DIFFERENCE						
	50 F	80 F	110 F	140 F	157.1 F	227.7 F	267.9 F
1/2	0.455	0.495	0.546	0.584	0.612	0.706	0.760
3/4	0.555	0.605	0.666	0.715	0.748	0.866	0.933
1	0.684	0.743	0.819	0.877	0.919	1.065	1.147
1 1/4	0.847	0.919	1.014	1.086	1.138	1.324	1.425
1 1/2	0.958	1.041	1.148	1.230	1.288	1.492	1.633
2	1.180	1.281	1.412	1.512	1.578	1.840	1.987
2 1/2	1.400	1.532	1.683	1.796	1.883	2.190	2.363
3	1.680	1.825	2.010	2.153	2.260	2.630	2.840
3 1/2	1.900	2.064	2.221	2.433	2.552	2.974	3.215
4	2.118	2.302	2.534	2.717	2.850	3.320	3.590
5	2.580	2.804	3.084	3.303	3.470	4.050	4.385
6	3.036	3.294	3.626	3.886	4.074	4.765	5.160
8	3.880	4.215	4.638	4.960	5.210	6.100	6.610
10	4.760	5.180	5.680	6.090	6.410	7.490	8.115
12	5.590	6.070	6.670	7.145	7.500	8.800	9.530

TABLE 2. HEAT LOSS FROM HORIZONTAL BARE BRIGHT COPPER PIPE
Expressed in Btu per hour per linear foot per degree Fahrenheit between the pipe and surrounding still air at 70 F

NOMINAL PIPE SIZE (INCHES)	HOT WATER (Type K Copper Tube)				STEAM (Standard Pipe Size Pipe)		
	120 F	150 F	180 F	210 F	227.1 F (5 Lb)	297.7 F (50 Lb)	337.9 F (100 Lb)
	TEMPERATURE DIFFERENCE						
	50 F	80 F	110 F	140 F	157.1 F	227.7 F	267.9 F
1/2	0.180	0.210	0.218	0.229	0.299	0.338	0.355
3/4	0.236	0.275	0.291	0.307	0.357	0.408	0.418
1	0.290	0.338	0.354	0.373	0.440	0.492	0.523
1 1/4	0.340	0.400	0.418	0.443	0.510	0.571	0.598
1 1/2	0.390	0.463	0.473	0.507	0.598	0.671	0.710
2	0.490	0.525	0.600	0.628	0.719	0.813	0.851
2 1/2	0.580	0.675	0.709	0.750	0.840	0.953	1.008
3	0.680	0.788	0.848	0.871	0.987	1.107	1.165
3 1/2	0.760	0.888	0.946	1.000	1.114	1.235	1.307
4	0.940	1.000	1.045	1.107	1.210	1.361	1.456
4 1/2	...	...	...	...	1.335	1.495	1.488
5	1.020	1.200	1.255	1.320	1.465	1.670	1.755
6	1.160	1.375	1.410	1.500	1.685	1.890	1.942
8	1.460	1.725	1.820	1.890	2.100	2.373	2.510

(dollars) $\div 13,000$ (Btu) $\times 2000$ (lb) $\times 0.55$ (efficiency) = \$0.804. The total cost of heat lost per year = 0.804×181.6 (thousand Btu) = \$146.00. (A closely approximate solution of such a problem may be made quickly by the use of the estimating chart given in Fig. 1.)

TABLE 3. HEAT LOSS FROM BRIGHT COPPER PIPE GIVEN ONE THIN COAT OF CLEAR LACQUER

Expressed in Btu per hour per linear foot per degree Fahrenheit between the pipe and surrounding still air at 70 F

NOMINAL PIPE SIZE (INCHES)	HOT WATER (Type K Copper Tube)				STEAM (Standard Pipe Size Pipe)		
	120 F	150 F	180 F	210 F	227.1 F (5 Lb)	297.7 F (50 Lb)	337.9 F (100 Lb)
	TEMPERATURE DIFFERENCE						
	50 F	80 F	110 F	140 F	157.1 F	227.7 F	267.9 F
1/2	0.240	0.265	0.282	0.307	0.401	0.461	0.478
3/4	0.320	0.356	0.373	0.414	0.477	0.571	0.578
1	0.390	0.437	0.463	0.507	0.598	0.681	0.710
1 1/4	0.470	0.537	0.554	0.614	0.700	0.812	0.840
1 1/2	0.540	0.612	0.645	0.714	0.830	0.966	0.990
2	0.690	0.762	0.818	0.892	1.005	1.164	1.201
2 1/2	0.840	0.937	0.991	1.085	1.178	1.361	1.420
3	0.960	1.025	1.135	1.270	1.400	1.625	1.700
3 1/2	1.100	1.250	1.318	1.442	1.580	1.845	1.905
4	1.241	1.400	1.480	1.556	1.750	2.040	2.130
4 1/2	.....	.....	.....	.....	1.910	2.240	2.350
5	1.480	1.685	1.790	1.965	2.130	2.415	2.610
6	1.700	1.936	2.052	2.272	2.450	2.810	2.990
8	2.200	2.500	2.630	2.854	3.120	3.425	3.730

TABLE 4. HEAT LOSS FROM HORIZONTAL TARNISHED COPPER PIPE

Expressed in Btu per hour per linear foot per degree Fahrenheit between the pipe and surrounding still air at 70 F

NOMINAL PIPE SIZE (INCHES)	HOT WATER (Type K Copper Tube)				STEAM (Standard Pipe Size Pipe)		
	120 F	150 F	180 F	210 F	227.1 F (5 Lb)	297.7 F (50 Lb)	337.9 F (100 Lb)
	TEMPERATURE DIFFERENCE						
	50 F	80 F	110 F	140 F	157.1 F	227.7 F	267.9 F
1/2	0.250	0.287	0.300	0.321	0.433	0.500	0.530
3/4	0.340	0.381	0.409	0.429	0.533	0.543	0.654
1	0.440	0.475	0.509	0.536	0.636	0.746	0.803
1 1/4	0.500	0.559	0.618	0.622	0.764	0.878	0.934
1 1/2	0.580	0.656	0.710	0.750	0.904	1.053	1.120
2	0.730	0.825	0.890	0.957	1.101	1.273	1.364
2 1/2	0.880	1.000	1.091	1.143	1.305	1.490	1.605
3	1.040	1.175	1.272	1.343	1.560	1.800	1.940
3 1/2	1.180	1.350	1.454	1.535	1.750	2.020	2.170
4	1.460	1.500	1.635	1.715	1.941	2.240	2.430
4 1/2	.....	.....	.....	.....	2.131	2.465	2.650
5	1.600	1.812	1.980	2.071	2.387	2.770	2.990
6	1.840	2.125	2.270	2.430	2.740	3.210	3.440
8	2.400	2.685	2.910	3.110	3.310	4.050	4.370

HEAT LOSSES FROM INSULATED PIPES

The conductivities of various materials used for insulating steam and hot water systems are given in Table 8. They are given as functions of the mean temperatures or the mean of the inner and outer surface tem-

TABLE 5. RADIATING SURFACE PER LINEAR FOOT OF PIPE

NOMINAL PIPE SIZE (INCHES)	SURFACE AREA (Sq Ft)	NOMINAL PIPE SIZE (INCHES)	SURFACE AREA (Sq Ft)	NOMINAL PIPE SIZE (INCHES)	SURFACE AREA (Sq Ft)
$\frac{1}{2}$	0.22	2	0.622	5	1.456
$\frac{3}{4}$	0.275	$2\frac{1}{2}$	0.753	6	1.734
1	0.344	3	0.917	8	2.257
$1\frac{1}{4}$	0.435	$3\frac{1}{2}$	1.047	10	2.817
$1\frac{1}{2}$	0.498	4	1.178	12	3.338

TABLE 6. RADIATING SURFACE PER LINEAR FOOT OF COPPER TUBING
Outside diameter $\frac{1}{8}$ in. greater than nominal size

TUBE SIZE (INCHES)	SURFACE AREA (Sq Ft)	TUBE SIZE (INCHES)	SURFACE AREA (Sq Ft)	TUBE SIZE (INCHES)	SURFACE AREA (Sq Ft)
$\frac{1}{2}$	0.164	2	0.556	5	1.342
$\frac{3}{4}$	0.229	$2\frac{1}{2}$	0.687	6	1.604
1	0.295	3	0.818	8	2.128
$1\frac{1}{4}$	0.360	$3\frac{1}{2}$	0.949	..	....
$1\frac{1}{2}$	0.426	4	1.080	..	....

TABLE 7. AREAS OF FLANGED FITTINGS, SQUARE FEET^a

NOMINAL PIPE SIZE (INCHES)	FLANGED COUPLING		90 DEG ELL		LONG RADIUS ELL		TEE		CROSS	
	Standard	Extra Heavy	Standard	Extra Heavy	Standard	Extra Heavy	Standard	Extra Heavy	Standard	Extra Heavy
1	0.320	0.438	0.795	1.015	0.892	1.083	1.235	1.575	1.622	2.07
$1\frac{1}{4}$	0.383	0.510	0.957	1.098	1.084	1.340	1.481	1.925	1.943	2.53
$1\frac{1}{2}$	0.477	0.727	1.174	1.332	1.337	1.874	1.815	2.68	2.38	3.54
2	0.672	0.848	1.65	2.01	1.84	2.16	2.54	3.09	3.32	4.06
$2\frac{1}{2}$	0.841	1.107	2.09	2.57	2.32	2.76	3.21	4.05	4.19	5.17
3	0.945	1.484	2.38	3.49	2.68	3.74	3.66	5.33	4.77	6.95
$3\frac{1}{2}$	1.122	1.644	2.98	3.96	3.28	4.28	4.48	6.04	5.83	7.89
4	1.344	1.914	3.53	4.64	3.96	4.99	5.41	7.07	7.03	9.24
$4\frac{1}{2}$	1.474	2.04	3.95	5.02	4.43	5.46	6.07	7.72	7.87	10.07
5	1.622	2.18	4.44	5.47	5.00	6.02	6.81	8.52	8.82	10.97
6	1.82	2.78	5.13	6.99	5.99	7.76	7.84	10.64	10.08	13.75
8	2.41	3.77	6.98	9.76	8.56	11.09	10.55	14.74	13.44	18.97
10	3.43	5.20	10.18	13.58	12.35	15.60	15.41	20.41	19.58	26.26
12	4.41	6.71	13.08	17.73	16.35	18.76	19.67	26.65	24.87	34.11

^aIncluding areas of accompanying flanges bolted to the fitting.

peratures of the insulations. It should be emphasized that they are the average values obtained from a number of tests made on each type of material, also that all variables due to differences in thickness, pipe sizes, and air conditions are eliminated. Individual manufacturer's materials will, of course, vary in conductivity to some extent from these values.

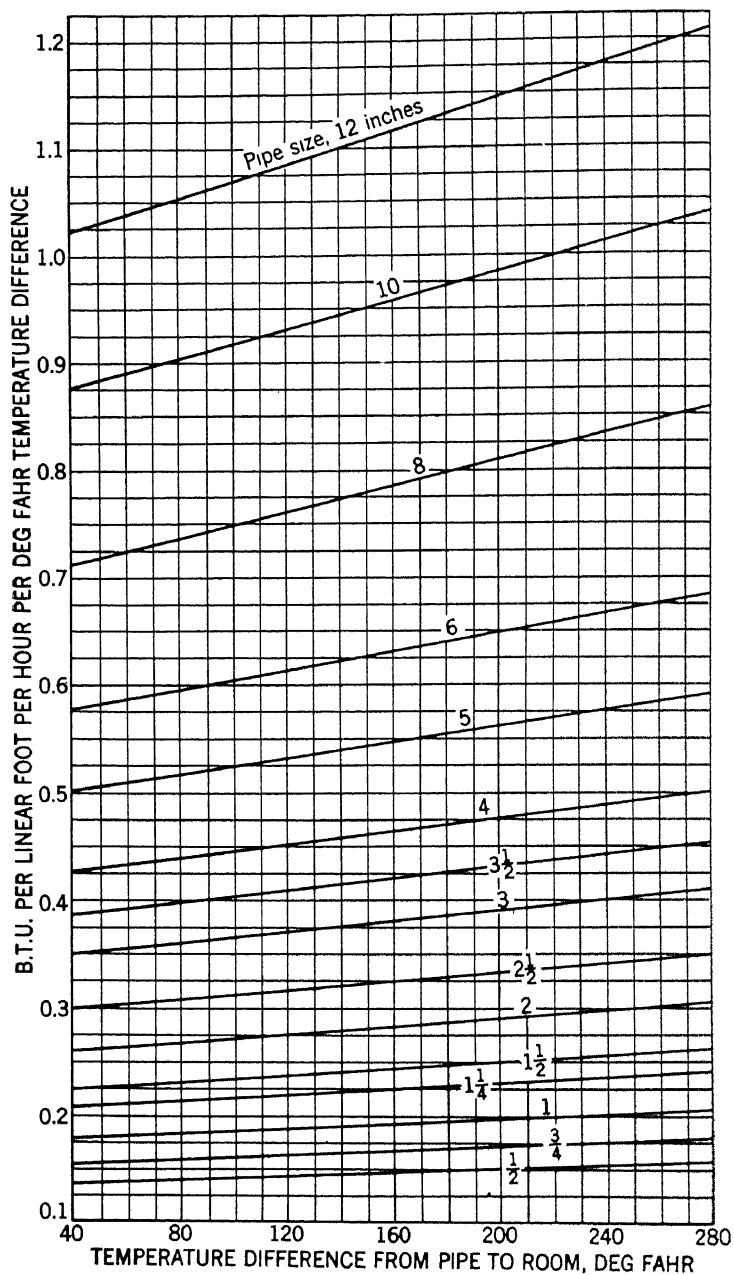


FIG. 2. HEAT LOSS THROUGH 1 IN. THICK 85 PER CENT MAGNESIA TYPE COVERING

The heat losses through 1, 1½, and 2-in. thick 85 per cent Magnesia type of insulation for temperature differences between the pipe and the surrounding atmosphere up to 280 F are shown in Figs. 2, 3, and 4. Standard thicknesses of 85 per cent Magnesia pipe covering are not exactly 1 in. However, the loss through any given thickness of insulation can be obtained by interpolation. Also, the losses through any of the

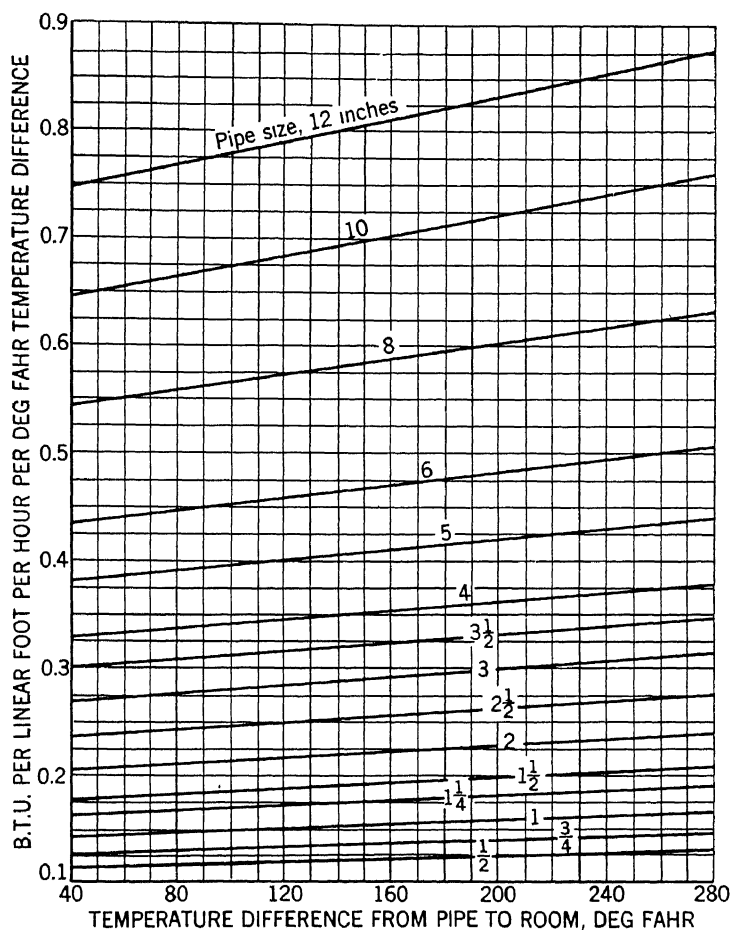


FIG. 3. HEAT LOSS THROUGH 1½ IN. THICK 85 PER CENT MAGNESIA TYPE COVERING

insulations given in Table 8 can be obtained by multiplying the losses obtained from Figs. 2, 3, or 4 by the factors given in Table 9.

The rate of heat loss from a surface maintained at constant temperature is greatly increased by air circulation over the surface. In the case of well-insulated surfaces, the increases in losses due to air velocity are very small as compared with increases from bare surfaces, because of the fact that air flowing over the surface of the insulation can increase only the rate of heat transfer from surface to air, and cannot change the internal

resistance to heat flow inherent in the insulation itself. The maximum increase in heat loss due to air velocity ranges from about 30 per cent in the case of 1-in. thick insulation, to about 10 per cent in the case of 3-in. thick insulation, provided that the insulation is thoroughly sealed so that air can flow only over the surface.

If the conditions are such that the air may circulate through cracks and crevices in the insulation, the increases may be far greater than those given. Therefore, it is essential that insulation be sealed as tightly as

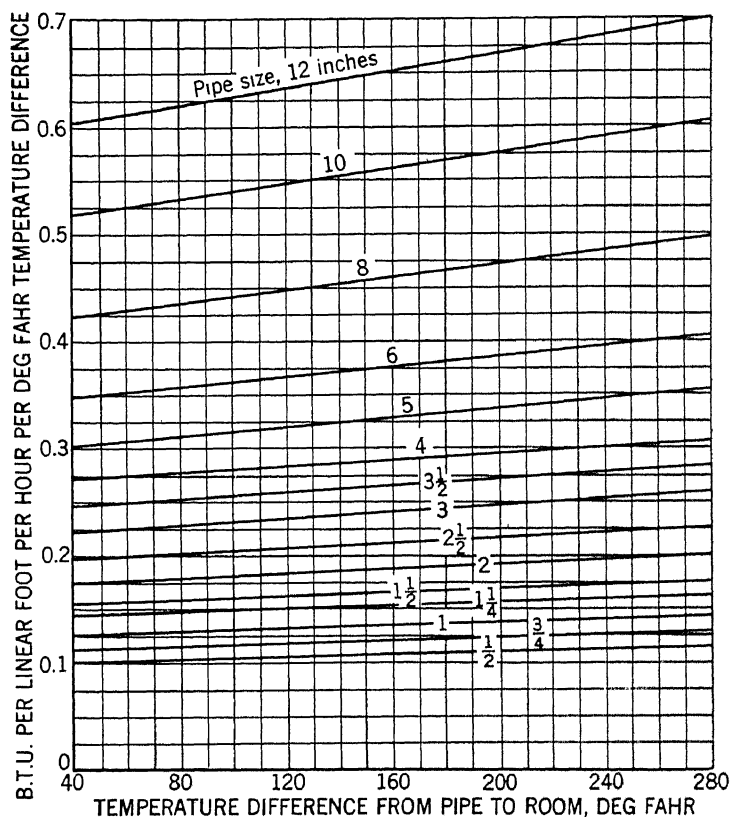


FIG. 4. HEAT LOSS THROUGH 2 IN. THICK 85 PER CENT MAGNESIA TYPE COVERING

possible. Pipe insulation exposed to the elements should be thoroughly waterproofed.

Example 3. If the steam line given in Examples 1 and 2 is covered with 1 in. thick 85 per cent magnesia, determine the resulting total annual loss through the insulation. Also compute the monetary value of the annual saving and the percentage of saving over the heat loss from the bare pipe.

Solution. By referring to Fig. 2, the coefficient for 1 in. magnesia on a 2 in. pipe is found to be 0.285 Btu per hour per linear foot of pipe per degree temperature difference at a temperature difference of 169.4 F. The total hourly loss per linear foot of pipe will then be $0.285 \times 169.4 = 48.3$ Btu. The total annual loss through the insulation = 48.3×165 (linear feet) $\times 4000$ (hours) = 31,900 Mb. The annual bare pipe loss as

CHAPTER 43. PIPE AND DUCT HEAT LOSSES

determined in the solution of Example 1 was found to be 181,600 *Mb*. The saving due to insulation is then 181,600 - 31,900 = 149,700 *Mb* per year.

From the solution of Example 2, it was found that the heat supplied to the system cost \$0.804 per thousand *Mb*. Therefore, the monetary value of the saving = 0.804 (dollars) \times 149.7 (thousand *Mb*) = \$120.36, or 82.4 per cent of the cost when using uninsulated pipe.

TABLE 8. CONDUCTIVITY (*k*) OF VARIOUS TYPES OF INSULATING MATERIALS FOR MEDIUM AND HIGH TEMPERATURE PIPES^a

TYPES OF INSULATING MATERIALS	MEAN TEMPERATURE, DEG F				
	100	200	300	400	500
85 per cent Magnesia Type.....	0.359	0.403	0.448	0.493	0.539
Corrugated Asbestos Type..... (4 Plies per 1 in. thick)	0.495	0.618	0.741	0.864	-----
Corrugated Asbestos Type..... (8 Plies per 1 in. thick)	0.505	0.598	0.692	0.786	-----
Laminated Asbestos Type..... (30-40 Laminations per 1 in. thick)	0.326	0.380	0.434	0.488	0.543
Laminated Asbestos Type..... (14-20 Laminations per 1 in. thick)	0.374	0.445	0.518	0.589	0.662
Mineral Wool Type.....	0.350	0.410	0.470	0.530	0.590
High Temperature Type..... (Diatomaceous Earth and Asbestos)	0.576	0.614	0.652	0.689	0.726
Brown Asbestos Type..... (Felted Fiber)	0.338	0.396	0.453	0.510	0.568

^aFrom tests conducted at *Mellon Institute*.

TABLE 9. PIPE COVERING FACTORS

TYPES OF INSULATING MATERIALS	TEMPERATURE DIFFERENCE, PIPE TO AIR, DEG F					
	100	200	300	400	500	600
85 per cent Magnesia Type.....	1.050	1.024	0.997	0.971	0.944	0.918
Corrugated Asbestos Type..... (4 Plies per 1 in. thick)	1.425	1.465	1.505	1.545	-----	-----
Corrugated Asbestos Type..... (8 Plies per 1 in. thick)	1.435	1.437	1.438	1.440	-----	-----
Laminated Asbestos Type..... (30-40 Laminations per 1 in. thick)	0.969	0.960	0.951	0.942	0.933	0.924
Laminated Asbestos Type..... (14-20 Laminations per 1 in. thick)	1.103	1.104	1.105	1.106	1.107	1.108
Mineral Wool Type.....	1.023	1.028	1.033	1.038	1.043	1.048
High Temperature Type..... (Diatomaceous Earth and Asbestos)	1.560	1.489	1.418	1.347	1.276	1.205
Brown Asbestos Type..... (Felted Fiber)	1.003	0.997	0.990	0.984	0.977	0.971

LOW TEMPERATURE PIPE INSULATION

Surfaces maintained at temperatures lower than the surrounding air are insulated to reduce the flow of heat and to prevent condensation and frost. The insulating material should absorb a minimum amount of moisture, because the absorption of moisture substantially increases the conductivity of the material. This property is particularly important in the insulation of surfaces that are below the dew-point of the surrounding

air. In such cases, due to vapor pressure difference, it is necessary to seal the surface of the insulating material against the penetration of water vapor which would condense within the material, causing a serious increase in heat flow, possible breakdown of the material, and corrosion of metal surfaces. An insulating material with a high degree of moisture absorption might pick up moisture before application and then, when

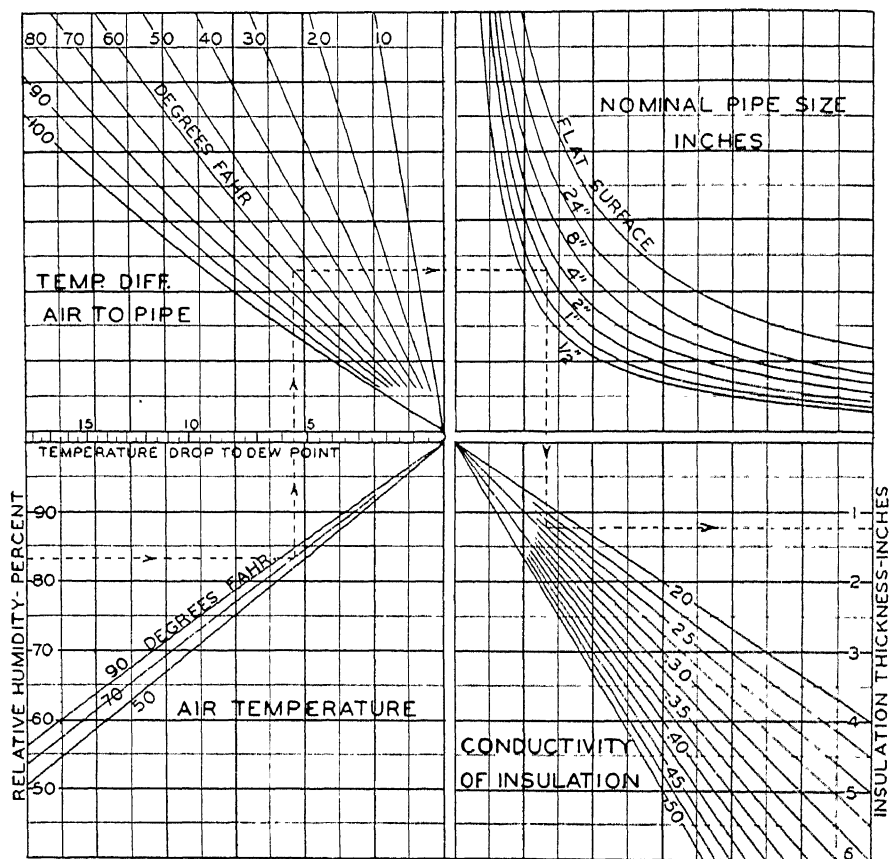


FIG. 5. THICKNESS OF PIPE INSULATION TO PREVENT SWEATING^a

^aSolve problems by drawing lines as indicated by dotted line, entering chart at lower left hand scale.

the seal is in place and the temperature of the insulated surface reduced, release that moisture to the cold surface.

The thickness of insulation required to prevent sweating is that thickness which will raise the temperature of the outer surface of the insulation to a point slightly higher than the dew-point for the corresponding air temperature and relative humidity. The difference in temperature between the air and the dew-point for various humidities can be readily ascertained from a psychrometric chart.

The approximate required thickness of insulation to prevent conden-

sation on pipes and flat metallic surfaces may be obtained from Fig. 5. The maximum permissible temperature drop is indicated at the point where the guide line passes through the horizontal scale at the left center of the chart. This temperature drop represents the difference between the dry-bulb temperature and the dew-point temperature for the conditions involved. (See discussion of Condensation in Chapter 4.) The surface resistances used for calculating the family of curves in Fig. 5 are based on tests made on canvas covered pipe insulation surfaces at *Mellon Institute*. However, it has been found that the resistance for asphaltic and roofing surfaces is practically the same as for canvas surfaces, so that the curves may be followed with no alteration for surfaces commonly used.

Heat gains for pipes insulated with a material having a conductivity of

TABLE 10. HEAT GAINS FOR INSULATED COLD PIPES

Rates of heat transmission given in Btu per hour per degree Fahrenheit temperature difference between fluid in pipe and surrounding still air

Based on materials having conductivity, $k = 0.30$

NOMINAL PIPE SIZE (INCHES)	ICE WATER THICKNESS			BRINE THICKNESS			HEAVY BRINE THICKNESS		
	Thickness of Insulation (Inches)	Btu Per Linear Foot	Btu Per Sq Ft Pipe Surface	Thickness of Insulation (Inches)	Btu Per Linear Foot	Btu Per Sq Ft Pipe Surface	Thickness of Insulation (Inches)	Btu Per Linear Foot	Btu Per Sq Ft Pipe Surface
$\frac{1}{2}$	1.5	0.110	0.502	2.0	0.098	0.446	2.8	0.087	0.394
$\frac{3}{4}$	1.6	0.119	0.431	2.0	0.111	0.405	2.9	0.094	0.340
1	1.6	0.139	0.403	2.0	0.124	0.352	3.0	0.104	0.294
$1\frac{1}{4}$	1.6	0.155	0.357	2.4	0.131	0.300	3.1	0.113	0.260
$1\frac{1}{2}$	1.5	0.174	0.351	2.5	0.134	0.270	3.2	0.118	0.238
2	1.5	0.200	0.322	2.5	0.151	0.244	3.3	0.134	0.214
$2\frac{1}{2}$	1.5	0.228	0.303	2.6	0.170	0.226	3.3	0.147	0.197
3	1.5	0.269	0.293	2.7	0.186	0.202	3.4	0.162	0.176
$3\frac{1}{2}$	1.5	0.295	0.282	2.9	0.191	0.183	3.5	0.176	0.167
4	1.7	0.294	0.248	2.9	0.209	0.176	3.7	0.182	0.154
5	1.7	0.349	0.239	3.0	0.241	0.165	3.9	0.202	0.138
6	1.7	0.404	0.233	3.0	0.259	0.150	4.0	0.228	0.130
8	1.9	0.455	0.201	3.0	0.318	0.140	4.0	0.263	0.116
10	1.9	0.559	0.198	3.0	0.383	0.135	4.0	0.309	0.110
12	1.9	0.648	0.194	3.0	0.438	0.131	4.0	0.364	0.108

0.30 Btu per square foot per hour per degree Fahrenheit difference per inch thickness are given in Table 10.

INSULATION OF PIPES TO PREVENT FREEZING

If the surrounding air temperature remains sufficiently low for an ample period of time, insulation cannot prevent the freezing of still water, or of water flowing at such a velocity that the quantity of heat carried in the water is not sufficient to take care of the heat losses which will result and cause the temperature of the water to be lowered to the freezing point. Insulation can materially prolong the time required for the water to give up its heat, and if the velocity of the water flowing in the pipe is maintained at a sufficiently high rate, freezing may be prevented.

Table 11 may be used for making estimates of the thickness of insulation necessary to take care of still water in pipes at various water and

surrounding air temperature conditions. Because of the damage and service interruptions which may result from frozen water in pipes, it is essential that an efficient insulation be utilized. This table is based on the use of a material having a conductivity of 0.30. The initial water temperature is assumed to be 10 F above, and the surrounding air temperature 50 F below the freezing point of water (temperature difference, 60 F).

The last column of Table 11 gives the minimum quantity of water at initial temperature of 42 F which should be supplied every hour for each linear foot of pipe, in order to prevent the temperature of the water from being lowered to the freezing point. The weights given in this column should be multiplied by the total length of the exposed pipe line expressed in feet. As an additional factor of safety, and in order to provide against

TABLE 11. DATA FOR ESTIMATING REQUIREMENTS TO PREVENT FREEZING OF WATER IN PIPES WITH SURROUNDING AIR AT -18°F

NOMINAL PIPE SIZE (INCHES)	NUMBER OF HOURS TO COOL 42 F WATER TO FREEZING POINT			WATER FLOW REQUIRED AT 42 F TO PREVENT FREEZING, POUNDS PER LINEAR FOOT OF PIPE PER HOUR		
	Thickness of Insulation in Inches (Conductivity, $k = 0.30$)					
	2	3	4	2	3	4
$\frac{1}{2}$	0.42	0.50	0.57	0.54	0.45	0.40
1	0.83	1.02	1.16	0.68	0.55	0.48
$1\frac{1}{2}$	1.40	1.74	2.02	0.84	0.68	0.58
2	1.94	2.48	2.90	0.95	0.75	0.64
3	3.25	4.27	5.08	1.24	0.94	0.79
4	4.55	6.02	7.20	1.47	1.11	0.93
5	5.92	7.96	9.69	1.73	1.29	1.06
6	7.35	9.88	12.20	1.98	1.46	1.19
8	10.05	13.90	17.25	2.46	1.78	1.43
10	13.00	18.10	22.70	2.96	2.12	1.70
12	15.80	22.20	28.10	3.43	2.45	1.93

temporary reductions in flow occasioned by reduced pressure, it is advisable to double the rates of flow listed in the table. It must be emphasized that the flow rates and periods of time designated apply only for the conditions stated. To estimate for other service conditions the following method of procedure may be used.

If water enters the pipe at 52 F instead of 42 F, the time required to cool it to the freezing point will be prolonged to twice that given in the table, or the rate of flow of water may be reduced so that the quantity required will be one-half that shown in the last column of Table 11. However, if the water enters the pipe at 34 F it will be cooled to 32 F in one-fifth of the time given in the table. It will then be necessary to increase the rate of flow so that five times the specified quantity of water will have to be supplied in order to prevent freezing.

If the minimum air temperature is -38°F (temperature difference 80 F) instead of -18°F , the time required to cool the water to the freezing point will be 60/80 of the time given in the table, or the necessary quantity of water to be supplied will be 80/60 of that given.

In making calculations to arrive at the values given in Table 11, the loss of heat stored in the insulation, the effect of a varying temperature

difference due to the cooling of pipe and water, and the resistance of the outer surface of the insulation to the transfer of heat to the air have all been neglected. When these factors enter into the computations it is necessary to enlarge the factor of safety. Also as stated, the time shown in the table is that required to lower the water to the freezing point. A longer period would be required to freeze the water but the danger point is reached when freezing starts. The flow of water will stop and the entire line will be in danger as soon as the water freezes across the section of the pipe at any point.

When water must remain stationary longer than the times designated in Table 11, the only safe way to insure against freezing is to install a steam or hot water line or to place an electric resistance heater along the side of the exposed water line. The heating system and the water line are then insulated so that the heat losses from the heating system are not

TABLE 12. THICKNESSES OF PIPE INSULATION ORDINARILY USED INDOORS^a

STEAM PRESSURES (LB GAGE) OR CONDITIONS	STEAM TEMPERATURES DEGREES FAHRENHEIT	THICKNESS OF INSULATION		
		Pipes Larger Than 4 in.	Pipes 2 in. to 4 in.	Pipes ½ in. to 1½ in.
0 to 25	212 to 267	1 in.	1 in.	1 in.
25 to 100	267 to 338	1½ in.	1 in.	1 in.
100 to 200	338 to 388	2 in.	1½ in.	1 in.
Low Superheat	388 to 500	2½ in.	2 in.	1½ in.
Medium Superheat	500 to 600	3 in.	2½ in.	2 in.
High Superheat	600 to 700	3½ in.	3 in.	2 in.

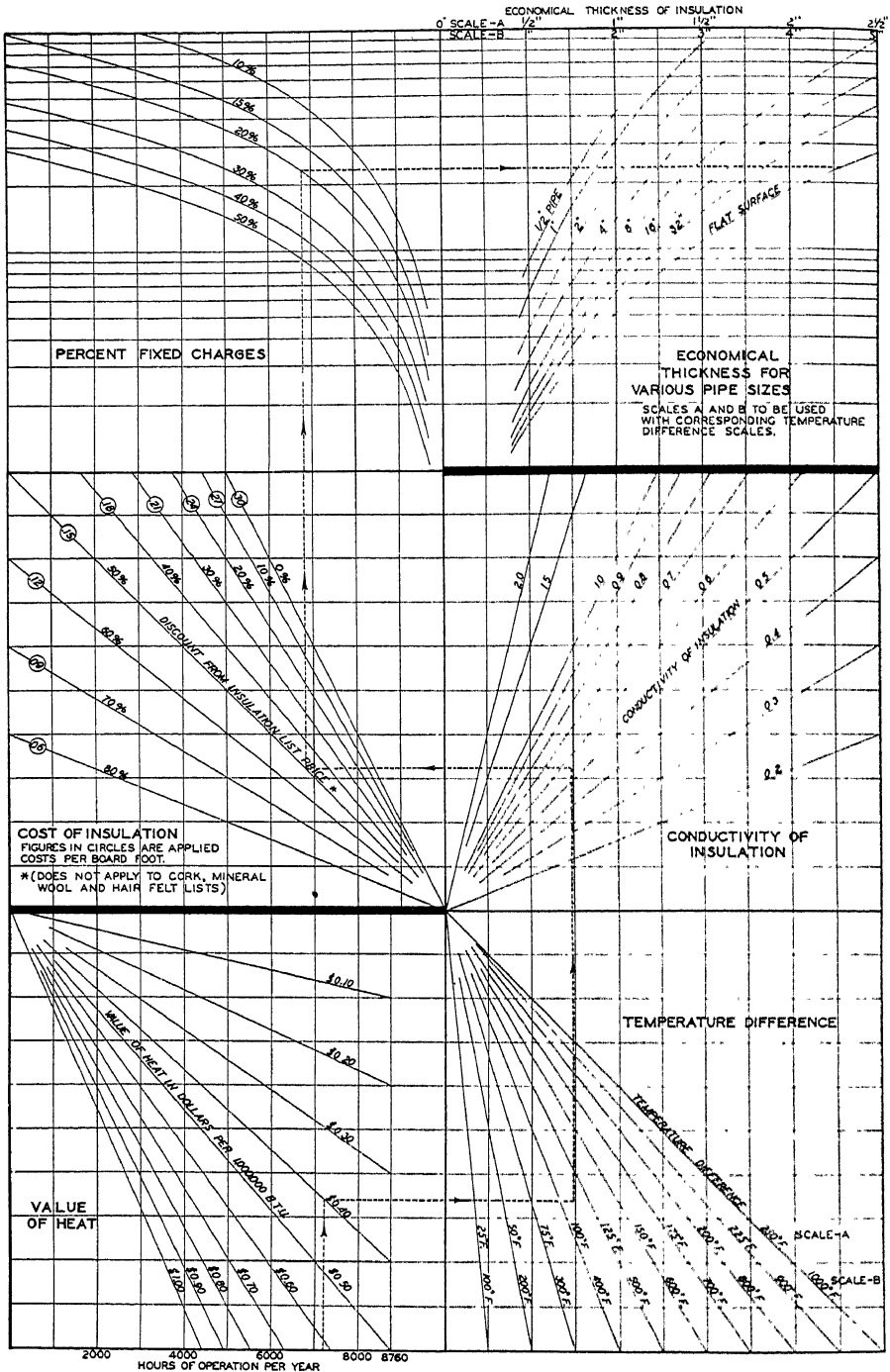
^aAll piping located outdoors or exposed to weather is ordinarily insulated to a thickness ½ in. greater than shown in this table, and covered with a waterproof jacket.

excessive, and the heating effect is concentrated against the water pipe where it is needed. For this form of protection 2 in. of an efficient insulation may be applied.

ECONOMICAL THICKNESS OF PIPE INSULATION

The thicknesses of insulation which ordinarily are used for various temperature conditions are given in Table 12. Where a thorough analysis of economic thickness is desired this may be accomplished through the use of the chart, Fig. 6.

The dotted line on the chart illustrates its use in solving a typical example. In using the chart, start with the scale at the left bottom margin representing the given number of hours of operation per year; then proceed vertically to the line representing the given value of heat; thence horizontally to the right, to the line representing the given temperature difference; thence vertically to the line representing the conductivity of the given material; thence horizontally, to the left, to the line representing the given discount on that material; thence vertically to the curve representing the required per cent return on the investment; thence horizontally to the right, to the curve representing the given pipe size; thence vertically to the scale at the top right margin where the economical thickness may be read off directly.



(L. B. McMillan, *Proc. National Dist. Heating Assn.*, Vol. 18, p. 138).

FIG. 6. CHART FOR DETERMINING ECONOMICAL THICKNESS OF PIPE INSULATION

UNDERGROUND PIPE INSULATION

Underground steam distribution lines are carried in protective structures of various types, sizes and shapes. (See Chapter 17.) Detailed data on commonly used forms of tunnels and conduit systems have been published by the *National District Heating Association*².

Pipes in tunnels are covered with sectional insulation to provide maximum thermal efficiency and are also finished with good mechanical protection in the form of metal or waterproofing membrane outer jackets. Conduit systems are in more general use than tunnels. Pipes carried in conduits may be insulated with sectional insulation; however, the more usual practice is to fill the entire section of the conduit around the pipes with high quality, loose insulating material. The insulation must be kept dry at all times, and for this purpose effective waterproofing membranes enclose the insulation. A drainage system is also provided to divert water which may tend to enter the conduit.

The economical thickness of insulation for underground work is difficult to determine accurately due to the many variables which have to be

TABLE 13. THICKNESS OF LOOSE INSULATION FOR USE AS FILL IN UNDERGROUND CONDUIT SYSTEMS

STEAM PRESSURES (LB GAGE) OR CONDITIONS	STEAM TEMPERATURES DEGREES FAHRENHEIT	MINIMUM THICKNESS OF INSULATION IN INCHES					MINIMUM DISTANCE BETWEEN STEAM AND RETURN
		STEAM LINES			RETURN LINES		
		Pipes Less than 4 In	Pipes 4 In to 10 In.	Pipes Larger than 12 In	Pipes Less than 4 In	Pipes 4 In and Larger	
Hot Water, or 0 to 25	212 to 267	1½	2	2½	1¼	1½	1
25 to 125	267 to 352	2	2½	3	1¼	1½	1¼
Above 125, or superheat	352 to 500	2½	3	3½	1¼	1½	1½

considered. As a result of theories³ previously developed, together with other experimental data which have been presented, the usual endeavor is to secure not less than 90 per cent efficiency for underground piping. Table 13 can be used as a guide in arriving at the minimum thickness of loose insulation fills to use for laying out conduit systems. Other factors such as the number of pipes and their combination of sizes, as well as the standard conduit sizes, are primary controlling factors in the amount and thickness of insulation for use.

When sectional insulation is applied to lines in tunnels or conduits, usual practice is to apply the most efficient materials ½ in. less in thickness than that determined by the use of Fig. 6. The data in Fig. 6 are based on conditions of insulation exposed to the air, whereas normal ground temperature is substituted for air temperature in determining the temperature difference for use with the chart when applying it for underground pipe line estimates.

²Handbook of the *National District Heating Association*, Second Edition, 1932.

³Theory of Heat Losses from Pipes Buried in the Ground, by J. R. Allen (A.S.H.V.E. TRANSACTIONS, Vol. 26, 1920, p. 335).

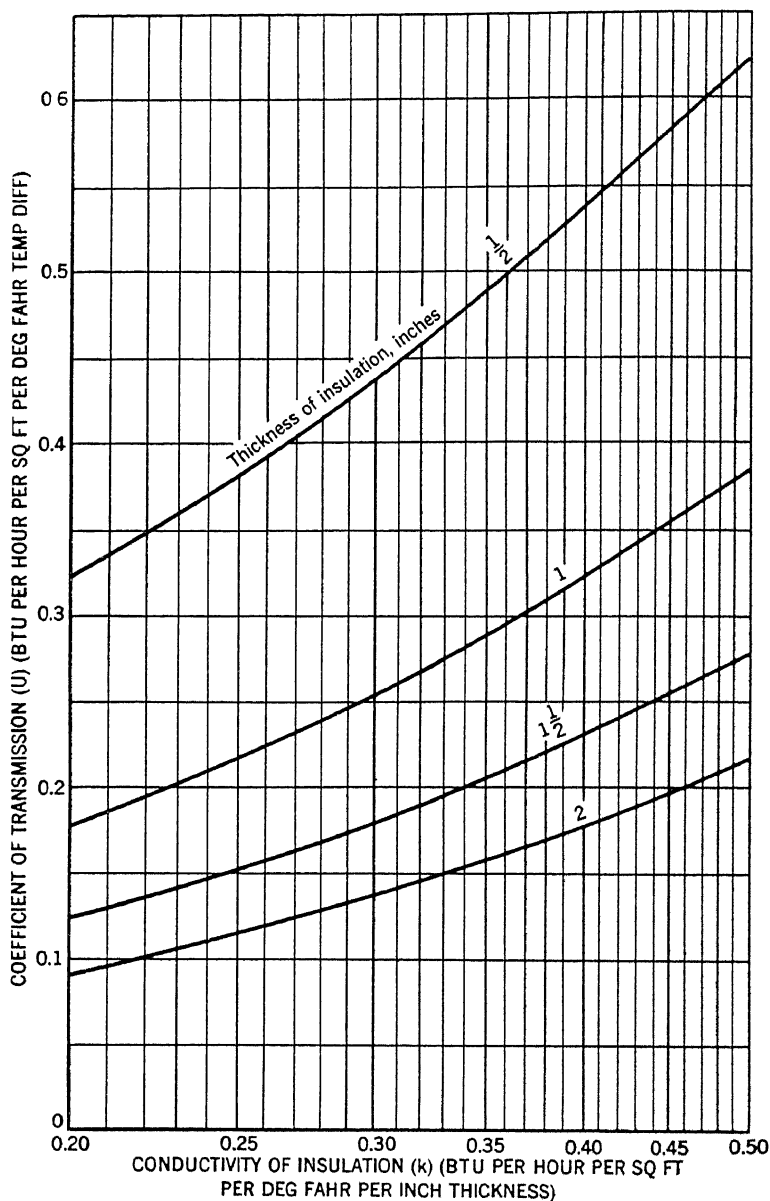


FIG. 7. HEAT LOSS COEFFICIENTS FOR INSULATED DUCTS^a

^aFor round ducts less than 30 in. diameter, increase heat transmission values by the following percentages:

THICKNESS OF INSULATION (Inches)	$\frac{1}{2}$	1	$1\frac{1}{2}$	2
21 to 30 in. Duct Diameter.....	1%	2%	3%	4%
12 to 21 in. Duct Diameter.....	3%	5%	7%	9%

HEAT LOSSES FROM DUCTS

The thermal transmission coefficient U for an uninsulated metal duct can be obtained from the equation:

$$U = \frac{1}{\frac{1}{f_i} + \frac{1}{f_o}} \quad (1)$$

where

U = thermal transmittance, Btu per square foot per hour per degree Fahrenheit difference in temperature between the average temperature inside the duct and the air outside the duct.

f_i = film conductance inside the duct, Btu per hour per square foot per degree Fahrenheit.

f_o = film conductance outside the duct, Btu per hour per square foot per degree Fahrenheit.

Film conductance f_i for air flowing in ducts apparently depends only on the velocity of the air and the diameter of the duct. A fairly reliable inside coefficient can be calculated from Schultz's modified equation:

$$f_i = \frac{0.32 V_o^{0.8}}{D^{0.25}} \quad (2)$$

where

V_o = velocity of air in duct, feet per second.

D = diameter of duct, feet.

Film conductance f_o depends on a number of variables including temperature, diameter, and emissivity of the outer surface and can readily be calculated from data in Chapter 3. From this explanation, it is seen that it is unwise to recommend a given value of U for all uninsulated metal ducts.

The heat loss from a given length of duct can be expressed by:

$$Q = UPL \left[\left(\frac{t_1 + t_2}{2} \right) - t_3 \right] \quad (3)$$

The heat given up by the air in the duct is:

$$Q = 0.24 M (t_1 - t_2) = 14.4 A V d (t_1 - t_2) \quad (4)$$

Equating 3 and 4 enables the determination of the temperature drop in the duct:

$$\frac{t_1 + t_2 - 2t_3}{t_1 - t_2} = \frac{28.8 A V d}{UPL}$$

Let $x = \frac{28.8 A V d}{UPL}$ for rectangular ducts, $= \frac{7.2 D V d}{UL}$ for round ducts, solving for t_1 and t_2 :

$$t_1 = \frac{t_2 (x + 1) - 2t_3}{(x - 1)} \quad (5)$$

$$t_2 = \frac{t_1 (x - 1) + 2t_3}{(x + 1)} \quad (6)$$

For low velocities and long ducts of small cross-section, a somewhat more accurate formula may be used as follows:

$$t_2 = \frac{t_1 - t_3}{e \left(\frac{UPL}{14.4 AdV} \right)} + t_3 \quad (7)$$

In these equations

Q = heat loss through duct walls, Btu per hour.

U = thermal transmission coefficient, Btu per square foot per hour per degree Fahrenheit.

P = perimeter of duct, feet.

L = length of duct, feet.

t_1 = temperature of air entering duct, degree Fahrenheit.

t_2 = temperature of air leaving duct, degree Fahrenheit.

t_3 = temperature of air surrounding duct, degree Fahrenheit.

M = weight of air per hour, through the duct, pounds.

A = cross-sectional area of duct, feet.

D = diameter of round ducts, feet.

V = velocity of air in the duct, feet per minute, at specified temperature.

d = density of air, pounds per cubic foot, at the specified temperature at which V is measured.

e = naperian base of logarithms = 2.718.

In using Equations 5, 6 and 7, one of the duct air temperatures will be unknown and will be solved for by substitution of the other known or assumed values.

Heat loss coefficients for insulated ducts with various conductivities are given in Fig. 7. The conductivities of various materials, which are based on mean temperatures, ranging from about 70 to 90 F, will be found in Table 2 of Chapter 4. For cases where the mean temperature is other than that on which the test was conducted, a correction should be made. However, in most cases the effect of this factor will be small and may be neglected.

Example 4. Determine the entering air temperature and heat loss for a duct 24×36 in. cross-section and 70 ft in length, insulated with $\frac{1}{2}$ in. of a material having a conductivity of 0.35 Btu at 86 F mean temperature, carrying air at a velocity of 1200 fpm, measured at 70 F, to deliver air at 120 F with air surrounding the duct at 40 F.

Solution. Referring to Fig. 7, the overall heat transmission coefficient is found to be 0.49 Btu. From Table 6, Chapter 1 the density of air at 70 F and 29.92 in. Hg. is found to be 0.0749 lb per cubic foot. Substituting these and the other given values in Equation 5:

$$x = \frac{28.8 \times 6 \times 0.0749 \times 1200}{0.49 \times 10 \times 70} = 44.4$$

$$t_1 = \frac{120 (44.4 + 1) - 80}{44.4 - 1} = 123.7$$

Substituting in Equation 3:

$$Q = 0.49 \times 10 \times 70 \left[\left(\frac{123.7 + 120}{2} \right) - 40 \right]$$

$$Q = 28.010 \text{ Btu per hour.}$$

Chapter 44

ELECTRIC HEATING

Resistors, Heating Elements, Electric Heaters, Unit Heaters, Central Fan Heating, Electric Boilers, Electric Hot Water Heating, Heating Domestic Water Supply, Radiant Drying, Reversed Cycle Refrigeration, Auxiliary Electric Heating, Control, Calculating Capacities, Power Problems

ELECTRIC heating is steadily assuming a more important place in heating, ventilating and air conditioning installations, encouraged in many localities by reduced electric rates. Electric heating is flexible, clean, safe, convenient and easy to control. It has many basic principles in common with fuel heating, but there are also important differences. When heat is delivered by wire, no combustion process is necessary, either at a central plant or at the individual room units. The output of an electric heater is a fixed constant, unaffected by the temperature of the surrounding air and it follows that the total load on an electric heating system is the total wattage of connected electric heaters, regardless of weather conditions. The main obstacle to the more general adoption of electric heating for buildings is the cost of the electricity itself.

All heat is a form of energy. Fuels hold stored chemical energy which is released into heat by combustion. Electrical power is a form of energy which can be released into heat by passing it through a resisting material. Both fuel and electric heating have two divisions: *first*, the conversion of energy into heat; *second*, the distribution and practical use of the heat after it is produced.

In converting the chemical energy of fuels into heat by combustion, there is necessarily a considerable variation in thermal efficiency. This is not true, however, when converting electric power into heat, as 100 per cent of the energy applied to the resistor is always transformed into heat. In electric heating practice no concern need be given to efficiencies of heat production, but rather to efficiencies of heat utilization. The problem is to distribute the electrically produced heat units in such manner as to obtain conditions of maximum comfort with the minimum consumption of electricity.

DEFINITIONS

Definitions of general terms used in fuel heating are given in Chapter 47. Terms which apply particularly to electric heating are:

Electric Resistor: A material used to produce heat by passing an electric current through it.

Electric Heating Element: A unit assembly consisting of a resistor, insulated supports, and terminals for connecting the resistor to electric power.

Electric Heater: A complete assembly of heating elements with their enclosure, ready for installation in service.

RESISTORS AND HEATING ELEMENTS

Solids, liquids, and gases may be used as resistors, but most commercial electric heating elements have solid resistors, such as metal alloys, and non-metallic compounds containing carbon. In some types of electric boilers, water forms the resistor which is heated by an alternating current of electricity passing through it. One of the more common resistors is nickel-chromium wire or ribbon which, in order to avoid oxidation, contains practically no iron.

Commercial electric heating elements are made in many types. Some have resistors exposed to the air being heated. The resistors may be coils of wire or metal ribbon, supported by refractory insulation, or they may be non-metallic rods, mounted on insulators. This type of element is used extensively for operation at high temperatures when radiant heat is desired, also at low temperatures for convection and fan circulation heating, especially in large installations.

Some elements have metallic resistors embedded in a refractory insulating material, encased in a protective sheath of metal. Fins or extended surfaces may be used to add heat-dissipating area. Elements are made in many forms, such as strips, rings, plates and tubes. Strip elements are used for clamping to surfaces requiring heat by conduction, and in some types of convection air heaters. Ring and plate elements are used in electric ranges, waffle irons, and in many small air heaters. Tubular elements may be immersed in liquids, cast into metal, and, when formed into coils, used in electric ranges and air heaters. Cloth fabrics woven from flexible resistor wires and asbestos thread, are used for many low temperature purposes such as heating pads and aviators' clothing.

Special incandescent lamps are used as heating elements in certain applications where radiant heat is desired. These use carbon or tungsten filaments as resistors, and are designed to produce maximum energy in the infra-red portion of the spectrum.

ELECTRIC HEATERS

Electric heaters may be divided into three groups: conduction, radiant and convection.

Conduction electric heaters, which deliver most of their heat by actual contact with the object to be heated, are used in such applications as aviators' clothing, hot pads, foot warmers, soil heaters, ice melters, and water heaters. Conduction heaters are useful in conserving and localizing heat delivery at definite points. They are not suitable for general air heating.

Radiant electric heaters, which deliver most of their heat by radiation, have high temperature heating elements and reflectors to concentrate the heat rays in the desired directions. The immediate and pleasant

sensation of warmth which is caused by radiant heat makes this type desirable for temporary use where the heat rays can fall directly upon the body. They are not satisfactory for general air heating, as radiant heat rays do not warm the air through which they pass. They must first be absorbed by walls, furniture, or other solid objects which then give up the heat to the air. For a discussion of electrically heated panels as applied to radiant heating, see Chapter 45.

Gravity convection electric heaters, designed to induce thermal air circulation, deliver heat largely by convection, and should be located and used in much the same manner as steam and hot water radiators or convectors. They generally have heating elements of large area, with moderate surface temperature, enclosed to give proper stack effect to draw cold air from the floor line. The flexibility possible with electric heating elements should discourage the use of secondary mediums for heat transfer. Water

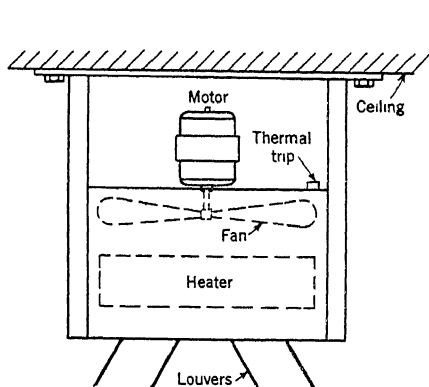


FIG. 1. CEILING MOUNTED UNIT HEATER

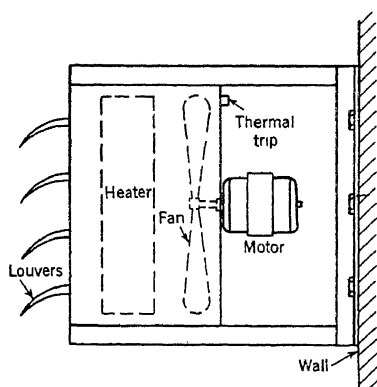


FIG. 2. WALL MOUNTED UNIT HEATER

and steam add nothing to the efficiency of an electric heater and entail expensive construction and maintenance.

UNIT HEATERS

Electric unit heaters include a built-in fan unit which circulates room air over the heating elements. Heaters of this type are manufactured in many designs and sizes, and can be located in the same manner as steam unit heaters.

Electric unit heaters are used in industrial plants, sub-stations, power houses, pumping stations, etc., where the power rate for electric heating is found to be favorable. In many large plants, such as flour mills, grain elevators, etc., in which there are a number of small offices, locker rooms, etc., scattered over wide areas, electric unit heaters are frequently economical in such locations. In small unattended stations, where freezing temperatures cannot be permitted, thermostatically-controlled electric unit heaters are frequently used to maintain a temperature above freezing. The best location for the heaters depends upon local circumstances as they can be mounted either on the ceiling to direct the air

downward, on the side wall about 7 ft from the floor, or near the floor line. Variations in design are necessary for different locations, but typical arrangements are indicated in Figs. 1 and 2.

The arrangement of the wiring circuits is very important for electric unit heaters. In principle they are all the same and include as essential elements an automatic control panel, a thermostat, and a master hand switch. All heaters should be designed with a safety thermal trip wired in series with the magnet coil of the control panel and with the hand switch and thermostat. A typical wiring diagram is shown in Fig. 3. This applies to a single phase power supply, but for 3-phase the only difference is to have a 3-pole panel and a heater arrangement for 3-phase connection.

Portable unit heaters are useful for temporary work, such as drying out damp rooms, or for warming rooms during construction.

CENTRAL FAN HEATING

Electric heating elements can be used for the prime source of heat in a central fan electric heating system or in the heating phase of a complete

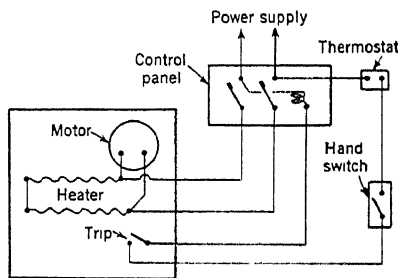


FIG. 3. WIRING DIAGRAM FOR UNIT HEATER

air conditioning system. They can be used in the same manner as steam heating units for tempering, preheating or reheating the air at the main supply fan location and as booster heaters at the delivery terminals of the duct system. In the humidification phase of air conditioning electric heating elements can be used to provide moisture by the evaporation of water, or for controlling air washer dew-point temperatures when mounted as preheating units on the intake side of the air washer. (See Chapter 21.)

In coordinating the input of heat energy and the volume of air circulation, a basic difference between electric heating and steam heating enters into the problem. Steam is approximately a constant-temperature source of heat for any given pressure and a change in air volume flowing over steam coils does not greatly affect the temperatures of the delivered air. The amount of steam condensed (heat input) varies in proportion to the air volume, but the surface temperature of the steam coils remains about the same. Electric heat is quite different, having a constant input of energy. If the volume of air flow over electric heating elements is changed, and no change is made in the electrical power connections, there will be a corresponding change in the temperature of the air delivered.

This occurs because the electrical energy input remains constant and the surface temperature of the heating elements will vary as is necessary to force the air to accept all the heat. With electric heat the total heat is constant unless some compensating action is performed by control. Automatic variation of the electrical heat input synchronized properly with the air flow can be successfully accomplished by various special methods of control.

Electric heaters are useful in balancing the heat distribution in central fan heating systems. Even in those instances where steam is the principal heat source, the temperature of individual rooms can be controlled locally by separate electric booster heaters. These heaters can be installed in branch ducts or behind the air outlet grilles in each room. With this arrangement, the central heating unit distributes air at an average temperature, controlled from a thermostat centrally located, such as in the main return duct. The electric booster heaters may be controlled by thermo-

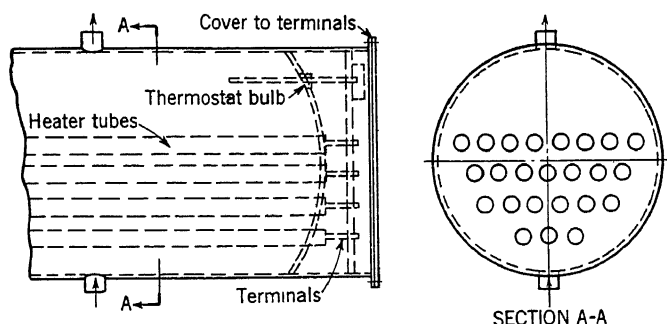


FIG. 4. RESISTANCE TYPE BOILER FOR STEAM OR HOT WATER

stats mounted in each individual room which permit the occupant to maintain any desired temperature independent of the rest of the building.

ELECTRIC BOILERS

Steam or hot water generating boilers using electric energy are entirely automatic and are well adapted to intermittent operation. Small electric boilers usually have heating elements of the enclosed metal resistor type immersed in the water. Boilers of this construction may be used either with direct or alternating current since the heat is delivered to the water by contact with the hot surfaces. To lessen the likelihood of the heating elements burning out, they should be of substantial construction, with a low heat density per unit of surface area and provision should be made for cleaning off desposits of scale which restrict the heat flow. A typical resistance type of steam or hot water boiler is shown in Fig. 4.

Large electric boilers are usually of the type employing water as the resistor, using immersed electrodes. With this type only alternating current can be used, as direct current would cause electrolytic deterioration. Such a type of electrode boiler is shown in Fig. 5.

Electric steam boilers are useful in industrial plants which require limited amounts of steam for local processes, and also for sterilizers, jacketed vessels and pressing machines which need a ready supply of steam. It sometimes is economical to shut down the main plant fuel burning boilers when the heating season ends, and to supply steam for summer needs with small electric steam boilers located close to the operation. In general, electric steam heating is confined to auxiliary or other limited applications. If the heating system is designed to use electricity exclusively, steam generating or distributing equipment is superfluous.

ELECTRIC HOT WATER HEATING

Electric water heating, using an electric boiler in place of a fuel burning boiler, like electric steam heating, is generally confined to auxiliary or

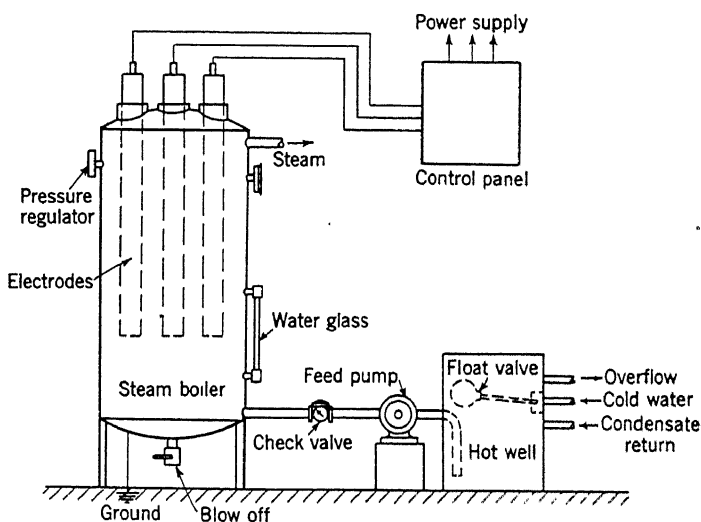


FIG. 5. DIAGRAMMATIC ARRANGEMENT OF AN ELECTRODE BOILER

other limited applications. The use of insulated water storage tanks, in which to store heat generated by electricity during off-peak hours at extremely low rates, is a development which has some special applications.

In this system of heating, the primary storage tank is simply a large, well-insulated, pressure type steel tank, equipped with electric heating elements and automatic time switches, which also have automatic limit controls for temperature and pressure. The heating system installed in the building may be of any standard individual radiator or fan-served indirect type or with provisions for the heating and humidification phases of an air conditioning system. A system of this kind requires very careful design to avoid excessive over-all radiation losses during periods of low heat demand. It is also important to provide for sudden changes in heat demand. A typical hot water heating boiler is illustrated in Fig. 4.

HEATING DOMESTIC WATER BY ELECTRICITY ¹

Electric water heaters of the automatic storage type for domestic hot water supply are simple and reliable. In many sections of the country low electric rates have been established by the electric utilities to secure this load. In some localities, electric rate schedules divide the current used for water heating into two classifications, regular and off-peak. A time switch automatically limits use of the off-peak heating element to the hours of off-peak load, while the regular heating element is a stand-by at all times. Storage of this two-element type of water heater is larger than average to carry over the periods when the off-peak element is timed out, without too frequent demands on the regular heating element which takes the higher domestic lighting service rate. Some utilities now offer

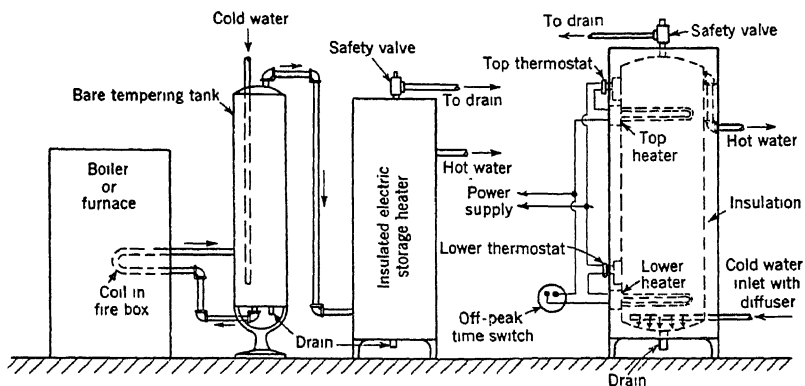


FIG. 6. PIPING ARRANGEMENT FOR CONNECTING ELECTRIC WATER HEATER TO FIRE-BOX COIL

FIG. 7. DOMESTIC HOT WATER HEATER FOR OFF-PEAK SERVICE

a schedule which, beyond a stipulated minimum, lowers the rate for all electric service if an electric water heater is installed.

Competition with other fuels, especially gas, seems to be the major controlling factor in the use of electricity. The first cost of electric storage heaters is also greater than for gas, owing to the need for larger tank storage due to off-peak service and slower recuperating capacity.

In residential work, to effect a saving in the cost of operation, it is sometimes desirable to use a furnace coil or indirect heater in connection with an electric water heater. In this case it is important to make the proper connections in order to benefit by any heat obtained from the furnace and at the same time to prevent dangerous overheating. The proper piping connections are shown in Fig. 6, and in this case the electric heater will only furnish heat when insufficient heat is supplied from the furnace. This arrangement has a further advantage in the summertime in that the bare tank through which the cold water passes on its way to

¹Test Results of Electric Water Heaters, by C. G. Hillier (A.S.H.V.E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, November, 1936, p. 632). Fourteenth Range and Water Heater Survey (*Electric Light and Power*, August, 1940).

the electric heater serves as a tempering tank, absorbing heat from the basement air and requiring the use of less energy in the electric heater.

A typical domestic hot water heater as shown in Fig. 7 is arranged with upper and lower heating elements for the usual type of off-peak heating service. The lower heating element is under the control of the off-peak time switch. However, the upper heating element is usually connected to the line so that in case the supply of hot water in the tank becomes exhausted the top thermostat can turn on the top heater and heat a small supply of water. The top heater will not heat the water in the tank below its location, but when the off-peak period arrives the lower heater is turned on and the entire tank becomes heated.

RADIANT DRYING

Lacquers and similar surface films can be very effectively dried by radiation. Special electric lamp bulbs have been developed which give off a high percentage of infra-red and similar heat rays². These are mounted in very efficient reflectors. For continuous manufacturing processes these reflectors are mounted in tunnels through which conveyors pass. For local applications, as for example paint drying in automobile repair shops, they may be mounted on portable racks.

In the application of this type of drying the composition of the paint or lacquer is important. In general, lacquers and those enamels using synthetic resins react most favorably. Other applications include the drying of ink, glue, and water, the softening of celluloid and bakelite for punching or shearing, and a wide variety of other uses.

REVERSED CYCLE REFRIGERATION

Reversed refrigeration is frequently referred to as a *heat pump* since the electric motor driving the refrigerating compressor furnishes the motive power to transfer heat from one temperature to a higher temperature level. The compressor acts as a reversible refrigerating unit to extract heat from the outdoor air in winter and deliver it indoors for heating purposes, and, by a reversal, to extract heat from the indoor air in summer and discharge it outdoors.

In normal use a refrigerating machine is arranged to remove heat and the heat removed is dissipated to the condenser cooling water. The driving energy is converted into heat, most of which is added to the heat removed and extracted. In so-called reversed refrigeration the heat removed together with the heat converted from the driving energy is utilized to heat the building. This conservation of the heat converted from the driving energy enables the reversed refrigeration to show a better performance in heating service than straight refrigeration can show in cooling service. In order to overcome the drop in capacity and in efficiency with lower outside temperatures, it is often desirable to use well-water instead of air as the source of heat. For a detailed description of this cycle see Chapter 25.

²Infra-Red Lamps Speed Up Drying Operations (*Automotive Industries* 82:376-7; April 15, 1940). Invisible Rays Build Visible Profits, by H. M. Archer (*Electric Light and Power*, May, 1940). Radiant Energy Drying and Baking for Organic Finishing (*Metal Industry* 38:294-6; May, 1940).

AUXILIARY ELECTRIC HEATING

In conjunction with heating systems of other types, an auxiliary electric heating arrangement is a convenient means of caring for mild days in the spring and fall which require little heat to make a building comfortable. Likewise, such electric heating might be used on abnormally cold days to help out the main heating system and by this means reduce the necessary size of the system.

A few installations have been made using electric heating cable buried in the floors of bathrooms, etc., to provide auxiliary electric heating. At least one airplane hangar is heated in this manner.

Because of the feeling of comfort that a radiant type heater gives, bathrooms may be heated electrically with this type of heater while the rest of the house is cared for by some other system. Offices and rooms which require heat at periods when the main heating plant is shut down can be conveniently heated electrically.

CONTROL

Because the efficiency of electric heat production is the same for small and large units, it is possible to reduce heat waste to a minimum by applying local heating, locally controlled. Heaters are often controlled manually but thermostatic control is essential for economical operation. For duct systems having a variable volume of air flow the electric heater control must automatically vary the heat input in coordination with the changes in air volume and demand for heat.

CALCULATING CAPACITIES

The electric heating capacity required can be calculated from the heat requirement in Btu per hour by using the equation:

$$\frac{\text{Btu per hour}}{3413} = \text{kw rating of required electric heating} \quad (1)$$

For comparison with steam radiation:

$$1 \text{ kw} = \frac{3413 \text{ Btu}}{240} = 14.2 \text{ sq ft of steam radiation} \quad (2)$$

POWER PROBLEMS

The cost of electric energy varies because of several factors. Distribution costs differ for large and small users. The fact that electricity cannot be economically stored, but must be used as fast as it is generated, makes it impossible to operate electric plants at uniform loads; hence, even the time of use may affect the cost of electricity. Special low rates are sometimes available during certain prescribed hours of use.

Since the cost of production and distribution depends not only upon the quantity of energy used but also upon the maximum rate at which it is used, electric energy is often sold on a demand rate basis. In some

cases, the demand charge is based upon the rated connected load, in other cases, upon the maximum demand as indicated by a demand meter.

Homes are almost universally supplied with lighting current of 115 volts, which can only be used economically for small heaters. Usually the service lines will not permit more than plug-in devices. The Underwriters permit approved heaters of 1320 watts or less to be plugged into approved baseboard receptacles, but such heaters cannot be served on a circuit supplying much other load without overloading the fuses. There is an increasing trend toward supplying homes with three wire 115/230 volt service. Where homes have such service, larger heaters can be installed. For industrial purposes, heaters should be designed to use polyphase power, which is usually supplied at 220, 440 or 550 volts. All polyphase heaters should be balanced between phases.

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Chapter 45

RADIANT HEATING

Physical and Physiological Factors, Control of Heat Losses, Rate of Heat Production, British Equivalent Temperature, Application Methods, Calculation Principles, Mean Radiant Temperature, Measurement and Control of Radiant Heating

FOR health and comfort, it is necessary for the rate of heat loss from the human body to be controlled by the aggregate effect of the conditions surrounding the body, so that the physiological reactions result in a feeling of comfort. No heating system serves the purpose of adding heat to the individual, but only reduces the net rate at which the body loses heat in cold weather by radiation, convection and evaporation. In convection methods of heating, the medium serves to maintain such an air temperature as will give comfort under existing conditions of humidity and of surrounding surface temperatures. The object of radiant heating, on the other hand, is to maintain an average temperature of the surrounding surfaces which will prevent too much heat loss from the human body by radiation, and thereby give comfort without needlessly heating the air. The difference between convection heating and radiant heating is therefore partly physical and partly physiological.

On a cold day, with no wind blowing, while standing in the sunshine, one may feel perfectly comfortable but, when a cloud passes over the sun, one will instantly feel much cooler. A shielded thermometer will show no immediate reduction in air temperature, so that one actually feels a cooling effect which an ordinary thermometer cannot register. This is because light and heat waves travel at the same speed and are both interrupted by the cloud, or other shield. This proves that heat rays affect the comfort of the body more quickly and more definitely than does air temperature.

It also proves that an ordinary thermometer registering the temperature of the air is not a criterion of comfort conditions. Healthful comfort requires that heat shall escape from the body at the same rate as it is generated by the oxidation of food in the body, and in a manner suitable to physiological requirements.

Furthermore, the ambient conditions will often cause changes both in the rate of heat generation in the body, and in the operation of the several methods by which the body loses heat. The feeling of heat or cold results not only from the rate at which the body loses heat, but also from the manner in which the heat is abstracted from the body, and the ease with

which the body's heat regulating mechanisms can operate. If the conditions of the environment and the state of the body are not perfectly correlated, a person is vaguely conscious of a strain in the thermostatic body mechanism.

CONTROL OF HEAT LOSSES

Heat is transferred from any warm dry surface to cooler surroundings principally by convection and by radiation; the total loss is substantially the sum of these two. Where the surface is moist, as with the human body, heat is also lost through evaporation from both the body surface and the respiratory tract.

The rate of heat loss by convection depends upon the average temperature difference between the surface of the body and the surrounding air, the shape and size of the body, and the rate of air motion over the body.

The rate of heat loss by radiation depends upon the exposed surface area of the body, and upon the difference between the mean surface temperature of the body and the mean surface temperature of the surrounding walls or other objects. This latter temperature is called the mean radiant temperature (MRT).

Because these two types of heat loss supplement each other, a required rate of total heat loss can result either from a relatively low air temperature and a relatively high MRT, or vice versa. It must be clearly understood, however, that while some conditions stimulate the production of heat in the body, others merely dissipate the heat without controlling the generation of heat.

A heating installation should provide comfort for those individuals doing the least physical work, without causing undesirable changes either in the rate of heat generation, or in the body's heat regulating mechanism.

Rate of Heat Production

The normal rate of heat production in an average sized sedentary individual is about 400 Btu per hour. The heat production for persons subjected to various rates of activity is given in Chapter 2. When considering radiant heating, one must study separately the evaporation, radiation and convection losses. The human body is of complicated shape, and radiation takes place freely only from the exposed outer surfaces; there are considerable portions of the body such as the legs, arms, lower part of head, etc., which radiate most of their heat to other portions. It is necessary to determine the equivalent surface of the body from which heat is radiated and a similar value for convection. The total surface may be assumed as approximately 19.5 sq ft for convection and 15.5 sq ft for radiation, in an average sized individual.

The loss by evaporation and respiration depends on the temperature and area of the moist surfaces (outside and respiratory) of the body, the air temperature, air movement and humidity. In air at a temperature of 70 F, this loss for a sedentary individual of average size will be approximately 90 Btu per hour; and at 60 F, about 70 Btu per hour. These values are relative, because the total will vary materially with change of position, bodily activity, age, sex, race, etc.

The balance of the heat generated in the average human body, approximately 300 to 320 Btu per hour at about 70 F room temperature, is the approximate amount of heat given off by radiation and convection. It is difficult to determine the exact proportions of these two; but it appears that if the body losses are about 190 Btu per hour by radiation, or 12.25 Btu per hour per square foot of radiating body surface, the greatest comfort will result. This leaves about 120 Btu per hour to be lost by convection, or 6.01 Btu per hour per square foot of convecting body surface.

The mean surface temperature of the human body, including the whole area not only of exposed skin but also of clothing and hair, has been estimated variously at from 75 F, particularly in England up to as high as 83 F in America. It is, however, conceded that further research and experience will be needed to finally derive the most suitable value for the American climate. The final figures will vary with sex, age, clothing, etc., but will probably come between these extremes. From installations already in use in America an average surface temperature of 80 F appears to be more nearly correct.

The mean surface temperature of an inert body, which will cause given rates of heat loss by radiation and by convection in a uniform environment, having a given air temperature and a given mean wall temperature, may be calculated from fundamental equations¹ for radiation and natural convection, with substitution of comparable cylinders for the irregular human body.

$$q_r = 0.1730 e \left[\left(\frac{T_s}{100} \right)^4 - \left(\frac{T_w}{100} \right)^4 \right] \quad (1)$$

$$q_c = 1.235 \left(\frac{1}{D} \right)^{0.2} \times \left(\frac{1}{T_m} \right)^{0.181} \times (T_s - T_a)^{1.266} \quad (2)$$

where

q_r = heat loss by radiation, Btu per square foot per hour.

q_c = heat loss by convection, Btu per square foot per hour.

T_s = absolute temperature of the body surface, degrees Fahrenheit.

T_w = absolute temperature of the walls, degrees Fahrenheit.

T_a = absolute temperature of the air, degrees Fahrenheit.

$$T_m = \frac{T_s + T_a}{2}$$

D = diameter of cylinder, inches.

e = the ratio of actual emission to black body emission.

If it is assumed that an average adult has a height of 5 ft 8 in. a body surface of 19.5 sq ft for convection, and 15.5 sq ft for radiation, an equivalent effect can be worked out for two cylinders, 5 ft 8 in. high by 13.15 in. diameter and 10.45 in. diameter, respectively. However, while the effects on a cylinder, of a particular size and shape may be used to estimate average similar effects on the human body, it should be remembered that the heat loss from the body varies greatly. Every movement alters not only its shape, but also the heat generated by the body and the velocity of the air passing over it and the surface exposed to radiation. This fact renders the results of any such computation only approximate.

¹Surface Heat Transmission, by R. H. Heilmann (*A.S.M.E. Transactions, Fuels and Steam Power Section*, Vol. 51, No. 22, September-December, 1929).

BRITISH EQUIVALENT TEMPERATURE

The British Equivalent Temperature (BET) is the mean temperature of the entire environment which is effective in controlling the rate of sensible heat loss from a *black body* in still air when this body has a surface temperature equal to that of the human body, and a size comparable to

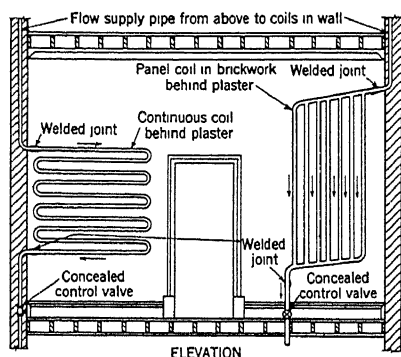


FIG. 1. COILS IN WALL SURFACES

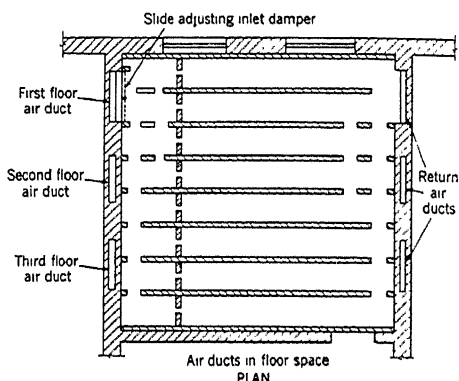


FIG. 2. AIR DUCTS FOR FLOOR HEATING

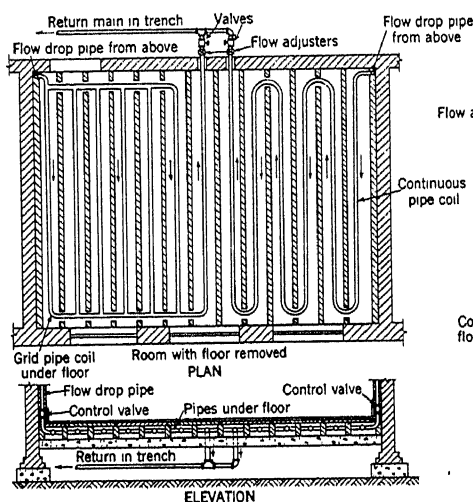


FIG. 3. CONTINUOUS COIL IN FLOOR

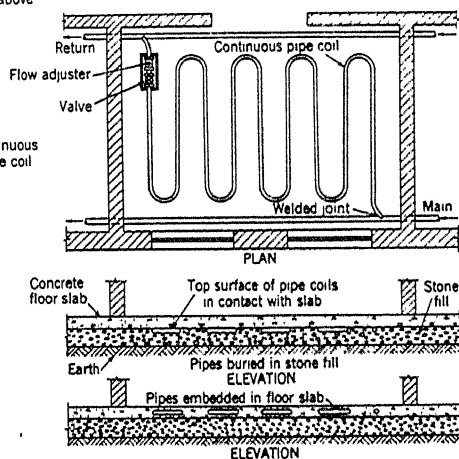


FIG. 4. COILS EMBEDDED IN FLOORS

the human body. The BET is, therefore, a function of both the air temperature and the mean radiant temperature of the surrounding objects. Its numerical value in a uniform environment with the walls and air at the same temperature is equal to the temperature of the walls and air. In a non-uniform environment, with the walls and air at different temperature, the BET for America is at present considered to be equivalent to that of a uniform environment in which a body with an 80 F surface

temperature will lose sensible heat at the same rate as in the given non-uniform environment. As originally defined in England, the BET was based on an average body surface temperature of 75 F, while 80 F seems to be more nearly conforming with American conditions. The most suitable temperature to assume will depend in part on the clothes worn by the individual. This explains why ladies in evening dress require a higher BET for comfort, than a man having only hands and head uncovered. The higher the BET, the less the heat loss from the body, as the rate of heat loss in still air is approximately proportional to the difference between the BET and the mean body surface temperature.

If the BET were 80 F, there could be no sensible heat loss from a surface at that temperature; so the temperature of a normal body surface would have to rise to a point where the heat generated in the tissues could be dissipated. Broadly speaking, it may be stated that with a BET of about 65 to 70 F, the sensible heat losses from the assumed average individual will approximate those previously stated.

APPLICATION METHODS

The several methods of applying radiant heating to a structure are:

1. *By warming the interior wall and ceiling surface of the building.* Pipe coils are embedded in the concrete or plaster of the walls or ceilings, the heating medium being hot water circulating through the pipe coils. These coils are generally constructed of small pipe $\frac{1}{2}$ or $\frac{3}{4}$ in. I.D. and spaced about 6 to 9 in. apart. See Fig. 1. This has the effect of warming the entire concrete or plaster surface in which the pipes are embedded. Since the temperature of the heating medium should never exceed about 130 F, due to the possibility of cracking the plaster the area of the warmed surface must be sufficient to supply the requisite quantity of heat at this low temperature. When carefully designed, this method produces very comfortable results and great operating economy, but offers some slight obstacles when alterations or additions to the building are desirable. Normally the hot water circulation is maintained by means of a circulating pump and facilities have to be provided to eliminate all air at the top of the system. All coils and circulating pipes are welded together and tested after erection to a hydraulic pressure of 300 lb per square inch.

2. *By circulating warm air through shallow ducts under the floor.* In this design the entire floor surface of a room is heated as in Fig. 2. This method was used 2000 years ago in many parts of the Roman Empire. While this method is more expensive in construction, it is effective and quite suitable for cathedrals and large public buildings. To provide a uniform floor temperature, one should give special consideration to the design of the air ducts so that equal heat distribution is obtained.

3. *By placing hot water or steam pipes under the floor.* With this arrangement the whole floor surface of a room is raised to a temperature sufficient to give comfortable conditions. Floor heating is recommended for schools and hospitals where large quantities of outside air are desirable. The floor surface may be of concrete, wood blocks, marble or any other material unaffected by heat, and while it is true that heat will be conducted through all materials used in floor construction, it is important that due consideration be given to the emissivity of the floor surface. In some cases where pipe coils are installed in the air space under the floor, special floors are constructed in sections so that the whole floor can be lifted to examine the coils. See Fig. 3. Pipes supported thus may be larger and the heating medium maintained at a higher temperature than when pipes are actually embedded in the floor. Pipes may be $1\frac{1}{2}$ or 2 in. in the former, but for the latter $\frac{3}{4}$ or 1 in. pipes are recommended. See Fig. 4. Where the heat losses from a room are exceptionally high it may be necessary to supplement the warm floor by either adding some coils in the ceiling or forming heated panels in the side walls.

4. *By attaching separate heated metal plates or panels to the interior surfaces.* These plates or panels are placed either in an insulated recess so that the surface of the panel is

flush with the surface of the walls or ceilings, or they may be secured to the face of the wall. They may be covered with wood veneers and decorated to harmonize with other parts of the room, or they may be cast into panels to imitate oak or other wood designs. With flat plate panels it is common practice to use a frame of plaster, wood, metal or composition to allow for expansion. These plates may be heated with either hot water or steam and connected as an ordinary radiator system. See Figs. 5 and 6.

5. *By electric heated metal plates or panels.* These plates or panels are either placed in insulated recesses of walls or ceilings or fastened to the construction, as found desirable. They should not have a surface temperature much above 200 F. Some have a much higher surface temperature but a lower temperature gives a more comfortable condition and is more efficient.

6. *By electrically heated tapestry mounted on screens and on the wall.* For this purpose

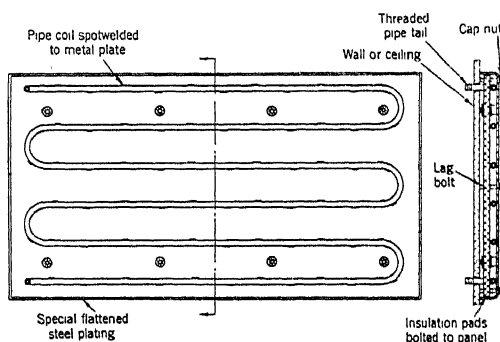


FIG. 5. PILLAR TYPE RADIANT HEAT PANEL

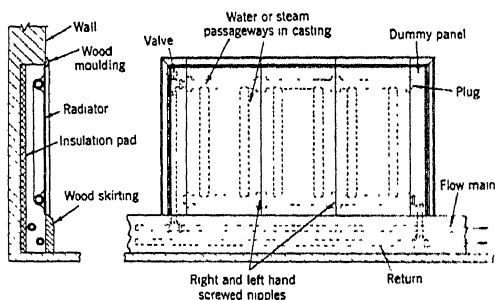


FIG. 6. FLAT TYPE PANEL INSTALLED IN WALL RECESS

the screen is woven with an electric continuous conductor. Such screens are useful to plug in at any position for emergency local heating without taking care of a large room or office.

Note. If all of a heating panel is installed at one end of a large room there may be a marked difference between the BET on the two sides of the body. It is usually desirable, therefore, that the heat be distributed at different parts of the walls and ceilings so that no uncomfortable effect will be felt from unequal heating.

CALCULATION PRINCIPLES

The calculations for radiant heating are entirely different from those for convective heating. The purpose of the latter is to determine and compensate for the rate of heat loss from the room, when the air tempera-

CHAPTER 45. RADIANT HEATING

ture is maintained at the desired conditions. Radiant heating, however, involves the regulation of the rate of heat loss from the human body in its several forms.

The first step in the calculations for radiant heating of a given room is to determine the desired mean radiant temperature, MRT; the second, to

TABLE 1. TOTAL RADIATION TO SURROUNDINGS AT ABSOLUTE ZERO^a

BODY OR MEAN RADIANT TEMPER- ATURE Deg Fahr	Radiation in Btu per square foot per hour emitted to surroundings with a tempera- ture of absolute zero by bodies at various temperatures and with emissivity factor ϵ				BODY OR MEAN RADIANT TEMPER- ATURE Deg Fahr	Radiation in Btu per square foot per hour emitted to surroundings with a temperature of absolute zero by bodies at various temperatures and with emissivity factor ϵ			
	ϵ 1.00	ϵ 0.95	ϵ 0.90	ϵ 0.80		ϵ 1.00	ϵ 0.95	ϵ 0.90	ϵ 0.80
30	99.3	94.3	89.4	79.4	71	136.5	129.6	122.9	109.3
35	103.5	98.3	93.2	82.8	72	137.4	130.5	123.6	109.9
40	107.6	102.4	96.8	86.1	73	138.4	131.5	124.5	110.6
45	112.1	106.5	100.9	89.7	74	139.6	132.6	125.6	111.7
46	112.9	107.3	101.6	90.4	75	141.0	133.9	126.9	112.8
47	113.9	108.2	102.5	91.1	80	146.6	139.4	132.0	117.4
48	114.8	109.1	103.4	91.9	85	152.3	144.6	137.1	121.9
49	115.6	109.9	104.1	92.4	90	157.9	149.9	142.1	126.4
50	116.5	110.6	104.9	93.2	100	169.6	161.1	152.6	135.7
51	117.5	111.6	105.8	94.0	110	181.6	172.5	163.5	145.4
52	118.4	112.5	106.5	94.7	120	194.8	185.0	175.4	155.9
53	119.4	113.4	107.4	95.5	130	210.1	199.6	189.1	168.1
54	120.2	114.2	108.2	96.2	140	223.2	212.1	201.0	178.5
55	121.1	115.1	109.0	96.9	150	237.1	225.2	213.5	189.7
56	122.1	116.0	109.9	97.7	160	251.1	238.8	226.0	201.0
57	123.1	117.0	110.9	98.5	170	270.5	257.0	243.5	216.4
58	124.0	117.8	111.6	99.2	180	288.0	273.8	259.1	230.4
59	124.9	118.6	112.4	99.9	190	306.5	291.0	275.8	245.1
60	125.8	119.5	113.4	100.7	200	325.2	309.0	292.8	260.3
61	126.6	120.3	114.0	101.4	210	348.0	330.6	313.1	278.4
62	127.7	121.4	114.9	102.2	220	371.5	353.0	334.4	297.1
63	128.6	122.2	115.8	102.9	250	437.8	415.9	394.0	350.2
64	129.6	123.1	116.7	103.7	300	575.0	546.1	517.5	460.0
65	130.5	124.0	117.5	104.4	350	740.0	703.0	666.0	592.0
66	131.6	125.0	118.4	105.4	400	942.1	895.0	847.5	753.5
67	132.5	125.9	119.3	106.0	450	1176.0	1117.0	1059.0	941.0
68	133.5	126.8	120.1	106.8	500	1464.0	1390.0	1318.0	1171.0
69	134.5	127.8	121.1	107.6	550	1791.0	1701.0	1613.0	1434.0
70	135.5	128.8	121.9	108.4	600	2405.0	2284.0	2165.0	1925.0

^aThese factors are calculated from the formula

$$q = \epsilon \left(\frac{0.1723 \times T^4}{100,000,000} \right)$$

where

q = total radiation, Btu per square foot per hour.

ϵ = emissivity.

T = absolute temperature, degrees Fahrenheit.

decide on the location of the heated surfaces; the third, to establish the temperature at which the heating surface shall operate; the fourth, to compute the size of the heating surfaces required to produce this MRT; the fifth, to calculate the actual heat loss from the room and to provide, if necessary, any additional convected heat beyond that given off by the radiant surfaces for the required number of air changes. If humidification

is required, this must be considered similarly to a conventional air conditioning system, except that the air temperature of the room will be much lower and will therefore require less moisture.

Mean Radiant Temperature

If the entire interior surface of a room were at the same temperature, this would be the MRT. Such a condition seldom exists, because in different parts of a room, some surfaces are exposed to the outer air while others are adjacent to heated rooms. The actual surface temperature varies with the construction and exposure of different sides of the enclosures. It is therefore necessary to calculate the thermal mean of these interior surface temperatures.

This is not the same as the arithmetic average of the various actual

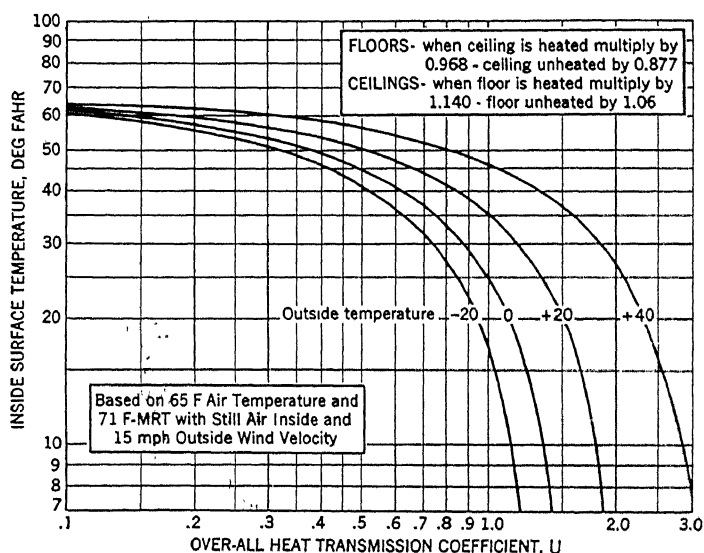


FIG. 7. CHART FOR ESTIMATING INNER SURFACE TEMPERATURES OF OUTSIDE VERTICAL WALLS

surface temperatures, but the radiant temperature which corresponds to the average of the several rates of heat emission (Btu per square foot) from the several surfaces. The emission at any given surface temperature, for any stated emissivity factor can be obtained directly from Table 1, while the emissivity factors for many materials may be found in Table 6 of Chapter 3. For example, from Table 1 it can be determined that if the emissivity of the surface is 0.90 then 1 sq ft of surface at 50 F will emit 104.9 Btu per square foot per hour to surroundings at absolute zero.

Such a determination of the amount of radiant heating surface needed in a room, to maintain a desired MRT, requires knowledge of the type of heating, and the temperatures of the unheated surfaces. The latter can be estimated from Fig. 7 which is based on an inside air temperature of 65 F and an MRT of 71 F. There will be some variation in surface

temperature with emissivity, but except in the case of reflective materials this may be neglected, as the variation due to ordinary building surfaces will be small.

Detailed Computation Method

Assuming the mean surface temperature of the exposed part of the human body and clothing to be 80 F and the emissivity factor to be 0.95, from Table 1 it can be determined that the body surface will give off 139.4 Btu per square foot per hour to absolute zero surroundings. Since the average human body releases approximately 12.25 Btu per square foot per hour by radiation, the mean radiant emission from the surroundings must be 127.15 Btu per hour with an average emissivity factor of 0.93 which requires an MRT of approximately 71 F. If the body is covered less so that the mean surface temperature of the body is 85 F with an emissivity factor of 0.95, the correct MRT for the room should be 74 F. Consequently, for baths and similar rooms the MRT should be slightly higher than for offices, etc. The mean radiant emission from walls, etc.,

TABLE 2. HIGHEST SAFE SURFACE TEMPERATURES FOR HEATING PANEL

TYPE OF PANEL	SURFACE TEMPERATURE DEG F
Plastered Ceiling (Pipes Embedded).....	115
Plastered Walls (Pipes Embedded).....	120
Floor, Any Method.....	85
Floor, Border and Aisles.....	120
Iron, Hot Water Medium ^a	160
Iron, Steam Vapor ^a	180
Electrically Heated Panels ^a	200

^aLow surface temperature radiation is recommended regardless of the heating medium employed.

to give this desired rate can be determined from Table 1. Multiplying by the total surrounding area will give the desired total radiant heat effect. Therefore the MRT for an ordinary living room, office, or similar room to give comfort conditions is 71 F.

The location of the surfaces is generally decided according to the type of building and its use. For high ceilings it is advisable to select floor heating or install heated panels in the walls at low level. For exposed rooms it may be necessary to have some wall or ceiling panels in addition to floor heating.

The temperature of the surface is controlled somewhat by the location. If the floor is chosen, then hot water pipes should be used as the medium; and the surface temperature should never be more than 85 F unless border heating is used. The latter comprises strips of heated surfaces where occupants will not usually rest their feet, such as portions of the floor adjacent to walls or windows, aisles of churches, halls, etc. If iron panels are used on side walls, etc., a surface temperature up to 160 F may be used with hot water as the heating medium. Vapor or low pressure steam may also be used with a maximum surface temperature of 180 F. For ceiling or other plaster heating, hot water pipes should be used with a

maximum water temperature of 130 F giving a surface temperature of about 115 F.

The area in square feet of each type or different surface temperature, horizontal or vertical, is multiplied by the emission value corresponding to its actual surface temperature. These products are added together to give the total radiant heat effect inside the room from all surfaces.

The difference between the desired and the actual total radiant emission represents the additional heating effect which must be supplied by the hot surfaces to be installed. The temperature of the proposed hot surface must then be selected from Table 2, and its emission per square foot at that temperature determined from Table 1. The difference between this emission and that of the unheated surface replaced by the panel is divided into the total amount of additional heat needed, and the quotient will be the area of the required heating surfaces.

These calculations depend on the accuracy of estimating the ultimate surface temperatures of the walls, windows, ceiling and floor surfaces

TABLE 3. ROOM DATA FOR SOLVING EXAMPLE

SURFACE	AREA Sq Ft	U	ESTIMATED INSIDE SURFACE TEMP DEG F	EMISSIVITY ϵ	HEAT EMIS- SION BTU PER Sq Ft PER HOUR	TOTAL HEAT EMISSION FROM AREA BTU PER HOUR
Outside Wall.....	297	0.25	55.0	0.95	115.1	34,200
Glass.....	279	1.13	33.6	0.92	94.3	26,300
Inside Wall.....	480	.....	60.0 ^a	0.95	119.5	57,300
Ceiling.....	480	0.20	60.4	0.95	119.8	57,500
Floor.....	480	0.10	60.0	0.93	117.0	56,200
Total.....	2,016			Avg. 0.93		231,500

^aNo heat loss through inside wall; assume wall surface temperature 60 F.

under comfort conditions. Some unheated surfaces will absorb a large number of heat rays from the heated panels and thereby become warmer, giving off rays of longer wave length, while other surfaces will reflect a large percentage of rays and become simple reflectors of heat. Windows will be affected largely by curtains, shades or venetian blinds and floors will be affected by rugs and carpets.

Example 1. The surface areas and over-all heat transmission coefficient for a residence room having a volume of 5760 cu ft are given in Table 3. Determine the amount of radiating surface to maintain a room air temperature of 65 F and an MRT of 71 F, with an outside temperature of zero, utilizing ceiling panels with circulating hot water at 130 F which will maintain a surface temperature of approximately 115 F as given in Table 2.

Solution. From Fig. 7 determine the estimated inside surface temperature for the various surfaces. In the case of the outside wall having a $U = 0.25$, it is found from the chart, that the intersection of this line with the zero outside temperature, that the surface temperature is 55 F.

Since the glass temperature will depend on whether or not shades or curtains are provided, it may be assumed in offices and similar rooms that the whole glass surface will be exposed, whereas in residences, curtains may cover all or part of the window thus increasing the room MRT and reducing the human body heat loss. For this example it is assumed that the windows are partly covered with side curtains to the extent of about

one-third. From Fig. 7 the surface temperature of the exposed glass corresponding to a $U = 1.13$, is 19 F. Assuming about a 2 F differential between the room air temperature and curtain surface temperature or 63 F, then one-third the difference between this value and the glass temperature results in a calculated average of 33.6 F.

With a ceiling $U = 0.20$, the surface temperature for an unheated ceiling from Fig. 7 is 57 F; multiplied by a factor $1.06 \times 57 = 60.4$ F. The surface temperature of the floor with a $U = 0.10$ is from Fig. 7 a value of 62 F; multiplied by a factor $0.968 \times 62 = 60$ F.

The emissivities are selected from Table 6, Chapter 3. The glass emissivity of 0.92 in Table 3 was determined by taking one-third of 0.95 (curtain) and two-thirds of 0.90 (glass). The heat emission in Btu per square foot per hour are taken from Table 1.

The approximate natural mean radiant emission of the room from data in Table 3 is $231,500 \div 2016 = 114.8$ Btu per square foot per hour which from Table 1 corresponds

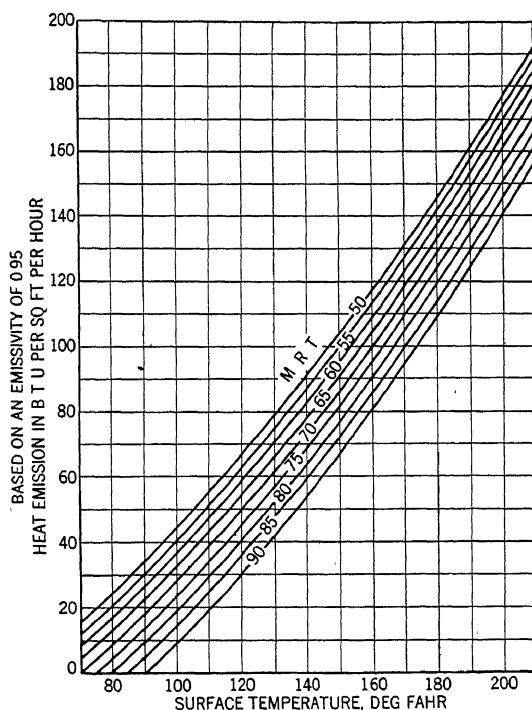


FIG. 8. HEAT EMISSION BY RADIATION FROM PANELS WHEN SURROUNDED BY SURFACES OF VARIOUS TEMPERATURES GIVING AN AVERAGE MRT ACCORDING TO CURVES

to an MRT of 57 F for an average emissivity of 0.93. With a ceiling surface temperature of 115 F and an emissivity of 0.95 from Table 1 the emission is 179.0 Btu per square foot per hour. The difference between 179 and 119.8 used in Table 3 is the additional heat emitted per square foot of warmed ceiling.

For an MRT of 71 F having a heat emission of 127 Btu corresponding to an average emissivity of 0.93, the total emission for all the room surfaces is $2016 \times 127 = 256,000$ Btu per hour. Or an additional $(256,000 - 231,500) = 24,500$ Btu per hour will be required. The heated ceiling at 115 F and 0.95 emissivity releases 179 Btu or $(179 - 119.8) = 59.2$ Btu per square foot per hour more heat than that allowed for an unheated ceiling. Therefore the surface required to be heated is approximately $24,500 \div 59.2 = 415$ sq ft.

Since the total ceiling area is 480 sq ft it is only necessary to utilize 415 sq ft to satisfy the necessary heating requirements. An alternative would be to heat the whole ceiling

surface using a lower temperature circulating water. Also with the entire ceiling heated a slight margin of safety will be provided which is an advantage.

Example 2. Using the data in Example 1 calculated directly the required surface temperature if the entire ceiling area is utilized and the design room conditions are identical.

Solution. From Example 1 it was shown that 256,000 Btu per hour were required to maintain the desired MRT in the room having a surface area of 2016 sq ft, and that 24,500 Btu of additional heat per square foot of ceiling was required above the natural heat emission of the room as shown in Table 3. Dividing 24,500 by 480 = 51.0 Btu per square foot per hour plus 119.8 Btu per square foot per hour which is the heat emission of the unheated ceiling gives 170.8 Btu. From Table 1 and for an emissivity of 0.95

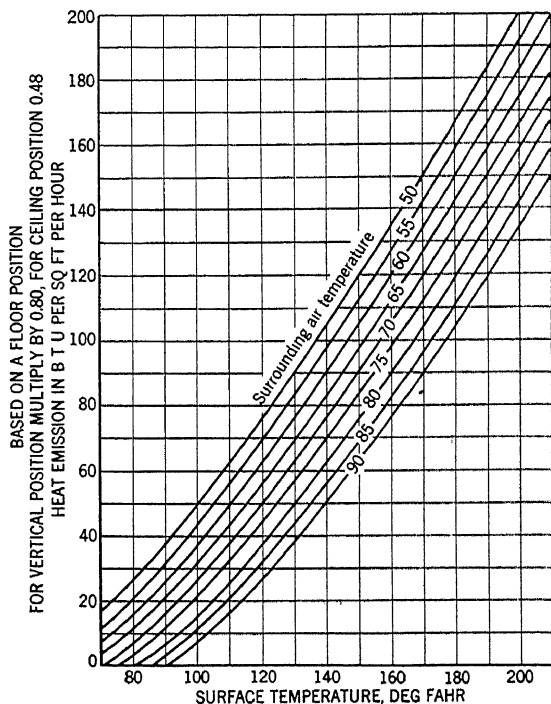


FIG. 9. HEAT EMISSION BY CONVECTION FROM RADIANT HEAT PANELS WITH STILL AIR AT VARIOUS TEMPERATURES

it is found that this amount of heat will be emitted from a surface at approximately 108.5 F.

This surface temperature may be obtained by using circulating water at about 125 F instead of 130 F, or the embedded pipes may be spaced wide apart and the water temperature maintained at 130 F.

Example 3. Determine the total heat emitted from the ceiling surface in Example 1 if it is maintained at a temperature to provide a room MRT of 71 F using the data in Figs. 8 and 9.

Solution. The calculated heat losses of the room as outlined in Chapter 6 are given in Table 4. The MRT for all unheated surfaces in the room may be determined from Table 3, by adding the total heat emission from walls, floors and windows and dividing by the total surface, or $174,000 \div 1536 = 113.5$ Btu per square foot per hour. From Table 1 this emission from a surface having an emissivity of 0.93 corresponds to about 55 F.

Utilizing the entire ceiling area with a heat emission corresponding to a surface tem-

perature of 108.5 F as determined in Example 2, and with a surrounding average MRT of the unheated surfaces of 55 F as previously calculated, it will be found from Fig. 8 that the ceiling surface will emit 50 Btu per square foot per hour by radiation. With an air temperature of 65 F this same surface will emit $(42 \times 0.48) = 20.2$ Btu per square foot per hour by convection according to Fig. 9. Then the,

$$\text{Total by radiation} = 480 \times 50 = 24,000$$

$$\text{Total by convection} = 480 \times 20.2 = 9,696$$

$$\underline{\hspace{1.5cm}} \\ 33,696 \text{ Btu per hour}$$

The difference between 33,696 and 33,460 Btu in Table 4 results in a safety factor of 236 Btu per hour.

In case the ventilation rate of the room had been increased, more heat could be furnished by either adding wall panels or by introducing a positive source of ventilation air which could be externally heated to the correct temperature.

TABLE 4. CALCULATED HEAT LOSSES FOR EXAMPLE

SURFACE	AREA Sq Ft	<i>U</i>	HEAT LOSS CALCULATION	TOTAL HEAT LOSS BTU PER HOUR
Outside Wall.....	297	0.25	$297 \times 0.25 \times (65 - 0)$	4,820
Exposed Glass.....	186	1.13 ^a	$186 \times 1.13 \times (65 - 0)$	13,650
Covered Glass	93	0.57 ^b	$93 \times 0.57 \times (65 - 0)$	3,440
Inside Wall.....	480	-----	No heat loss next to heated room	-----
Ceiling.....	480	-----	Heated surface	-----
Floor.....	480	0.10	$480 \times 0.10 \times (65 - 0)$	3,120
Infiltration.....	$5760 \text{ cu ft} \times 1.25 \text{ air changes} \times (65 - 0) \times 0.018$			8,430
	Total			33,460

^aTwo-thirds window area assumed to be fully exposed with a $U = 1.13$.

^bOne-third window area protected by side curtains with a reduction $U = 0.57$.

MEASUREMENT OF RADIANT HEATING

Convection heating, intended to maintain a given air temperature, is best measured by thermometric methods, which indicate the air temperature, and not the rate of heat loss from the human body. Radiant heating aims to control this rate of heat loss and can be measured only by calorimetric methods.

The apparatus for this purpose consists essentially of a cylinder, maintained at the accepted mean surface temperature of the human body, together with an accurate (usually electrical) measuring of the varying rate of heat supply required to maintain this exact temperature. This instrument, the *eupatheoscope*, is readily adapted to function like a thermostat so as to turn heat on or off, when the desired temperature of 80 F, or any other predetermined surface temperature of the cylinder, decreases or increases as a result of changes in the BET.

For testing work, the *globe thermometer* is a useful instrument. It consists of an ordinary mercury thermometer, with its bulb placed in the center of a sphere from 6 to 9 in. in diameter, usually made of thin copper and painted black and sometimes covered with cloth. The temperature

recorded by thermometer with its bulb in the center of the sphere is termed the *radiation-convection temperature*. See Chapter 35.

CONTROL OF RADIANT HEATING

The effectiveness of any type of control will largely depend on the time lag of the system. With warm air passing through floor ducts the time lag is usually too long for any kind of room thermostat, in fact this type of thermostat will not prove suitable with any system if the building is constructed with massive brickwork and masonry, unless it operates in conjunction with a time control responsive to changes in outside conditions.

The heat emitted by hot water pipes embedded in the plaster of the

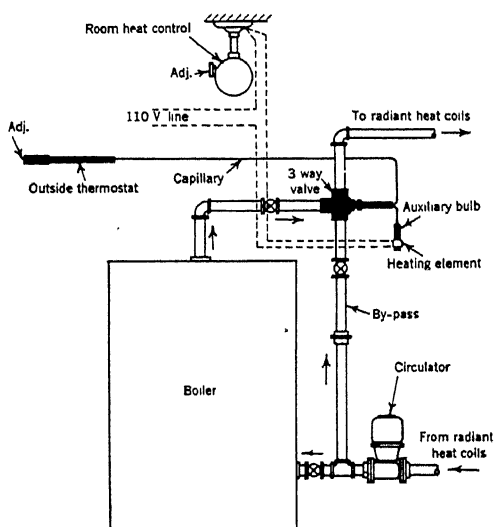


FIG. 10. TYPICAL RADIANT HEAT CONTROL SYSTEM

ceiling and walls or in the concrete base of a floor can be effectively controlled by an instrument designed to modulate the temperature of the water circulating in the system according to the outside conditions. Metal panels which can be installed in the ceiling or side walls may be either controlled by an instrument responsive to outside weather conditions or by a specially designed instrument responsive to both air temperature and radiation. Any purely *on or off* control system is not recommended for radiant heating.

A typical control system operated from an outside thermostat, and supplemented with a room heat control instrument is illustrated in Fig. 10. The outside thermostat modulates the temperature of the circulating water in the coils by introducing some of the hot water leaving the boiler with a proportionate amount of return water which is diverted to the three-way valve.

One type of room instrument consists of a blackened copper sphere of

6 or 8 in. in diameter, in which a cylindrical sump contains a volatile liquid. A small electric heating coil creates in the sphere a vapor pressure which remains constant as long as the total heat loss from the sphere is at the desired rate. If the BET becomes too high for comfort, a greater vapor pressure results from the smaller heat loss from the sphere. This acts on a diaphragm and reduces the supply of heat to the room. With too low a BET the reverse action occurs. A similar instrument which has an electric heating element for warming the air inside the sphere and thermostat operated switch is also used for controlling room conditions.

In addition to a thermostatically controlled device for modulating the temperature of the circulating water, it is an advantage to insert in each coil a locked flow control or adjustable resistance to give uniform conditions throughout all rooms. Owing to unforeseen difficulties with varying frictional losses in pipes, emission factors and exposures it is an advantage to be able to permanently regulate the flow through each circuit by means of a key operated valve as indicated in Fig. 4.

FUEL CONSUMPTION

Because of the lower air temperature desired with radiant heating, there is a possible saving in fuel consumption. This saving depends very largely on the method employed to heat the surfaces and the provision made to prevent heat passing from the coils to the earth or outside air.

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Chapter 46

WATER SUPPLY PIPING AND WATER HEATING

Maximum Flow, Factor of Usage, Water Pressure, Pipe Material, Allowance for Fittings, Sizing Up-Feed Systems, Sizing Down-Feed Systems, Hot Water Supply, Storage Capacity and Heating Loads, Methods of Heating Water, Computing Grate and Coil Surface Area, Controls, Solar Water Heaters

THIS chapter deals only with problems of providing adequate facilities for delivering cold and heated water for domestic purposes in buildings.

The amount of cold or warm water used in any building is a variable depending on type of building, usage, occupancy and time of day. The problem is to provide the piping and the water heating and storage facilities of sufficient capacity to meet the peak demand without wasteful excess in equipment of cost¹. For example, in two office buildings of similar type the metered water consumption has shown as much as 300 per cent difference per outlet. The rate of use in such buildings also fluctuates tremendously with the hour of day.

Residences present a comparatively easy problem since long established custom has evolved reliable factors for water consumption per installed fixture. Tests have been made repeatedly of the amount of water required by standard fixtures in normal use with water at ordinary pressures so that this information gives a fairly correct basis of design.

For the purpose of this chapter the following terms will be used and should be clearly distinguished from one another:

Maximum Flow: The flow which would occur if the outlets on all fixtures were opened simultaneously. This condition is seldom obtained in actual practice except in cases of gang showers controlled from one common valve.

Probable Flow: The maximum flow which any pipe is likely to carry under the peak conditions. This is the most important amount to be considered in pipe sizing.

Average Flow: The flow likely to be required through the line under normal conditions.

¹See also Methods of Estimating Loads in Plumbing Systems, by R. B. Hunter (*National Bureau of Standards*, Report BMS65, 1940). Plumbing Manual, Report of the Subcommittee on Plumbing, Central Housing Committee on Research, Design and Construction (*National Bureau of Standards*, Report BMS66, 1940). Water-Distributing Systems for Buildings, by R. B. Hunter (*National Bureau of Standards*, Report BMS79, 1941). Water Consumption, Cost and Savings, by G. C. St. Laurent (*American Hotel Association, Hotel Engineering*, Vol. 1, 1940). Laundry, Kitchen and Hospital Equipment, by H. C. Russell (*A.S.H.V.E. TRANSACTIONS*, Vol. 35, 1929, p. 45).

It is evident that any pipe size adequate to take care of the *probable flow* will also be more than ample to take care of the *average flow*, and hence the latter has no bearing on the pipe size.

MAXIMUM FLOW

An estimate of maximum flow for various fixtures regardless of type of building with the water at about 35 lb pressure is given in Table 1.

To obtain the probable flow from Table 1, it is necessary to multiply the maximum flow by a factor of usage, and this factor varies with the

TABLE 1. APPROXIMATE MAXIMUM FLOW FROM FIXTURES UNDER NORMAL WATER PRESSURES

FIXTURES	COLD WATER (GALLONS PER MINUTE)	HOT WATER (GALLONS PER MINUTE)
Water-closets, flush valve.....	45 ^a	0
Water-closets, flush tank.....	10	0
Urinals, flush valve.....	30 ^a	0
Urinals, flush tank.....	10	0
Urinals, automatic tank.....	1	0
Urinals, perforated pipe per foot.....	10	0
Lavatories.....	3	3
Showers, 4 in. heads, $\frac{1}{2}$ in. inlets.....	3	3
Showers, 6 in. heads or larger.....	6	6
Needle bath.....	30	30
Shampoo spray.....	1	1
Liver spray.....	2	2
Manicure table.....	1½	1½
Baths, tub.....	5	5
Kitchen sink.....	4	4
Pantry sink, ordinary.....	2	2
Pantry sink, large bibb.....	6	6
Slop sinks.....	6	6
Wash trays.....	3	3
Laundry tray.....	6	6
Garden hose bibb.....	10	0

^aActual tests on water-closet flush valves indicate 40 gpm as the maximum rate of flow with 30 lb pressure at the valve; this would increase to 60 gpm (about 50 per cent) at 90 lb pressure. The 45 gpm has been taken as an average flow; possibly, with very low pressures just sufficient to operate the flush valve, 30 gpm could be allowed with safety. Urinal flush valves would vary proportionately in the same manner.

type of occupancy and with the number of fixtures in the installation. With only two fixtures it is possible that both will at some time be in operation simultaneously. With 200 fixtures, however, it is unlikely that the entire 200 would ever operate at the same time. Consequently, the factor of usage becomes smaller as the number of fixtures becomes greater, all other things being equal.

The maximum flow per fixture for cold water should be totaled independently of that for hot water, and the sum of the two may be used in computing the probable flow through the incoming cold water supply main.

FACTOR OF USAGE

The principal plumbing fixtures subject to wide variation in water demand is a flush valve closet, and also shower baths, especially those in

gymnasiums, and buildings of that type, and also in manufacturing plants where the outgoing shifts create a heavy peak.

The curves of Fig. 1 suggest a method of selecting a factor of usage. The curve at the left should be followed for hot water piping and for cold water if the system has gravity tank closets, while the curve to the right allows amply for the influence of flush valve closets.

For example, if the product of the number of plumbing fixtures in a building multiplied by the proper values in Table 1 totals say 620 gal of water as the maximum flow, when using flush tank closets, the factor of usage from Fig. 1 will be about 23 per cent, and the probable flow will be $620 \times 0.23 = 143$ gpm. This is the first item to be determined in the design of a water supply system. In a building using 143 gpm no serious difference in the size of the main supply pipe would be occasioned by use of flush valves, since the factor of usage with the latter would be increased only to about 25 per cent or 155 gpm.

The curves of Fig. 1 are believed conservative for toilet rooms in large office buildings which have early business hour peaks, especially in the men's toilets, but may not be conservative enough for plants such as gymnasiums and manufacturing plants where heavy peak demands occur during certain hours. The proper usage percentage for such cases must be a matter of judgment and might properly approach 100 per cent. The average flow will usually be considerably smaller.

Example 1. Assume that in a normal building, such as a residential hotel or an apartment house, there are 50 flush valve water-closets, 50 lavatories, 50 sinks and 50 baths, and that it is desired to determine the probable flow in a line supplying all of these fixtures with both cold and hot water.

Cold Water

50 W. C. x 45 gpm.....	2250 gpm
50 Lavs. x 3 gpm.....	150 gpm
50 Sinks x 4 gpm.....	200 gpm
50 Baths x 5 gpm.....	250 gpm
Maximum flow.....	2850 gpm

Fig. 1 shows a factor of usage of 9 per cent.

Probable flow of cold water is
 $2850 \times 0.09 \dots\dots\dots 257$ gpm

Hot Water

50 Lavs. x 3 gpm.....	150 gpm
50 Sinks x 4 gpm.....	200 gpm
50 Baths x 5 gpm.....	250 gpm
Maximum flow.....	600 gpm

Fig. 1 shows a factor of usage of 23 per cent.

Probable flow of hot water is $600 \times 0.23 \dots\dots\dots 138$ gpm

Total for main supplying cold and hot water (2850 + 600) $\times 0.08 \dots\dots\dots 276$ gpm

It should be noted that this is a *rate of flow* or an *instantaneous demand*.

WATER PRESSURE

The usual practice in buildings of moderate height is to place the water supply mains near the basement ceiling, with up-feed risers feeding the various fixtures on the upper floors. In tall buildings the pressure due to the weight of the water becomes so great as to limit the service to vertical sections not exceeding about 20 stories in height. Beyond this approximate limit the valves on the lower stories will be noisy.

For these reasons, the considerations of this chapter are limited to horizontal mains and to risers which serve not more than 20 stories. In taller buildings it is usual to install separate horizontal mains for each superimposed zone.

The minimum practicable size of piping for any water system is

governed by the amount of pressure which can be spared in overcoming resistance to flow of a given volume of water per unit of time. After the approximate amount of water required has been computed, a minimum delivery pressure at the highest fixture may be determined, which should be approximately 15 lb per square inch. It should be remembered that for every foot in height there will be a hydrostatic loss of head of 0.433 lb.

The pressure loss through a water meter may be significant as may be seen from Table 2. The pressure losses through filters or other water-conditioning apparatus also must be considered. After evaluating the previously mentioned factors, the total allowable friction loss for the

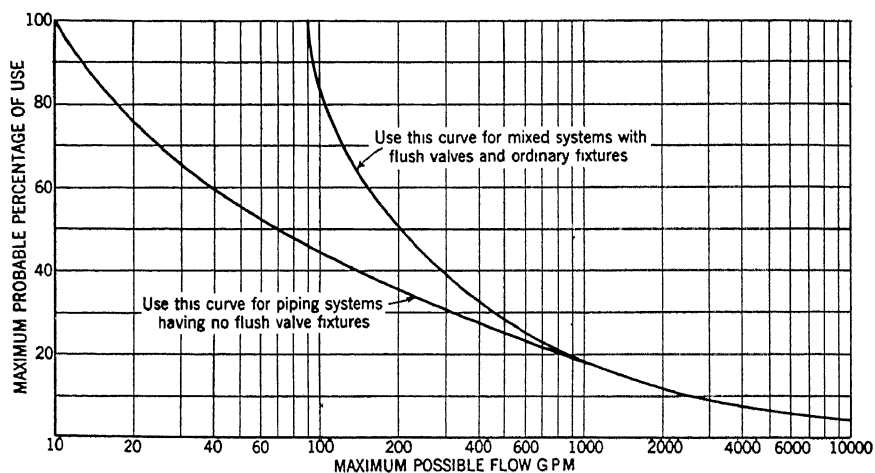


FIG. 1. CHART SHOWING RELATION BETWEEN MAXIMUM FLOW AND PROBABLE USAGE

system may be determined by subtracting from the street main pressure, the sum of the following four items:

1. Minimum allowable pressure at top fixture.
2. Meter loss.
3. $0.433 \times$ height in feet from main to top fixture.
4. Loss for filters, softener, etc.

PIPE MATERIAL

The material used in the water piping affects its carrying capacity. For example, copper or brass pipe is not as likely to retain interior incrustation as is ferrous pipe, and galvanized pipe will not rust as quickly as uncoated pipe. Some waters tend to deposit salts, rust, and the like on the interior surfaces of pipes, greatly reducing their capacity. In some cities it has been found necessary to allow for as much as 50 per cent reduction in carrying capacity after 15 years of service.

The data given in this chapter are based on use of galvanized steel piping and on water which is not notoriously inclined to leave deposit. If the building is in a zone having untreated water known to carry precipitable solids, the pipe sizes should be increased at least one size and no water pipe should be smaller than $\frac{3}{4}$ in.

CHAPTER 46. WATER SUPPLY PIPING AND WATER HEATING

TABLE 2. PRESSURE LOSS THROUGH WATER DISC METERS^a
A. W. W. A. Standards

RATE OF FLOW GPM	APPROX PRESSURE LOSS THROUGH METERS, LB PER SQ IN. PIPE SIZE (IN.)							
	½	¾	1	1½	2	3	4	6
5	1.5	0.5	0.2					
10	6.0	2.0	1.0	0.2				
15	14.0	5.0	2.0	0.6	0.2			
20	25.0	9.0	3.5	1.0	0.4			
25		13.5	5.5	1.5	0.6			
30		19.5	8.0	2.0	0.9			
35			11.0	3.0	1.0			
40			14.0	4.0	1.5			
45			18.0	5.0	2.0			
50			22.0	6.0	2.5	0.7		
75				14.0	5.5	1.5		
100				25.0	10.0	2.8	1.0	
125					15.0	4.0	1.5	
150					22.0	6.0	2.2	
175						8.0	3.0	
200						10.4	4.0	1.0
250						16.0	6.0	1.5
300						23.0	9.0	2.2
350							12.0	3.0
400							16.0	4.0
500							25.0	6.5
600								9.0
800								16.0
1000								25.0

MINIMUM SIZE OF SERVICE RECOMMENDED						SAFE MAXIMUM DELIVERY OF METERS	
RATE OF FLOW GPM	APPROX. MINIMUM PIPE SIZE OF SERVICE, MAIN TO METER (IN.) MAXIMUM LENGTH (Ft)					METER SIZE IN.	CAPACITY, GPM BASED ON 25 LB LOSS THROUGH METER
	30	75	100	150	200		
1-20	¾	¾	1	1	1	5/8	20
						¾	34
20-30	¾	1	1	1	1½	1	53
						1½	100
30-50	1	1½	1½	1½	1½	2	160
50-100	1½	1½	2	2	2	3	315
						4	500
100-150	1½	2	2	2½	2½	6	1000

^aPressure loss through compound and current meters is less than shown in table. For exact information consult manufacturers.

ALLOWANCE FOR FITTINGS

Before applying charts for pipe friction, the resistance due to fittings and valves should be evaluated. Table 3 gives this resistance expressed in equivalent feet of straight pipe. To use Table 3, the size of the valve or fitting must be known. Table 3 is therefore of little use in the original design of a system, since the valve and fitting allowances must be made before the pipe size is known. Experience indicates, however, that an average increase of 50 per cent in the length of the longest measured pipe will account for the fittings, and thus a tentative length can be assumed for computing the pressure drop per 100 ft of run. The values of Table 3

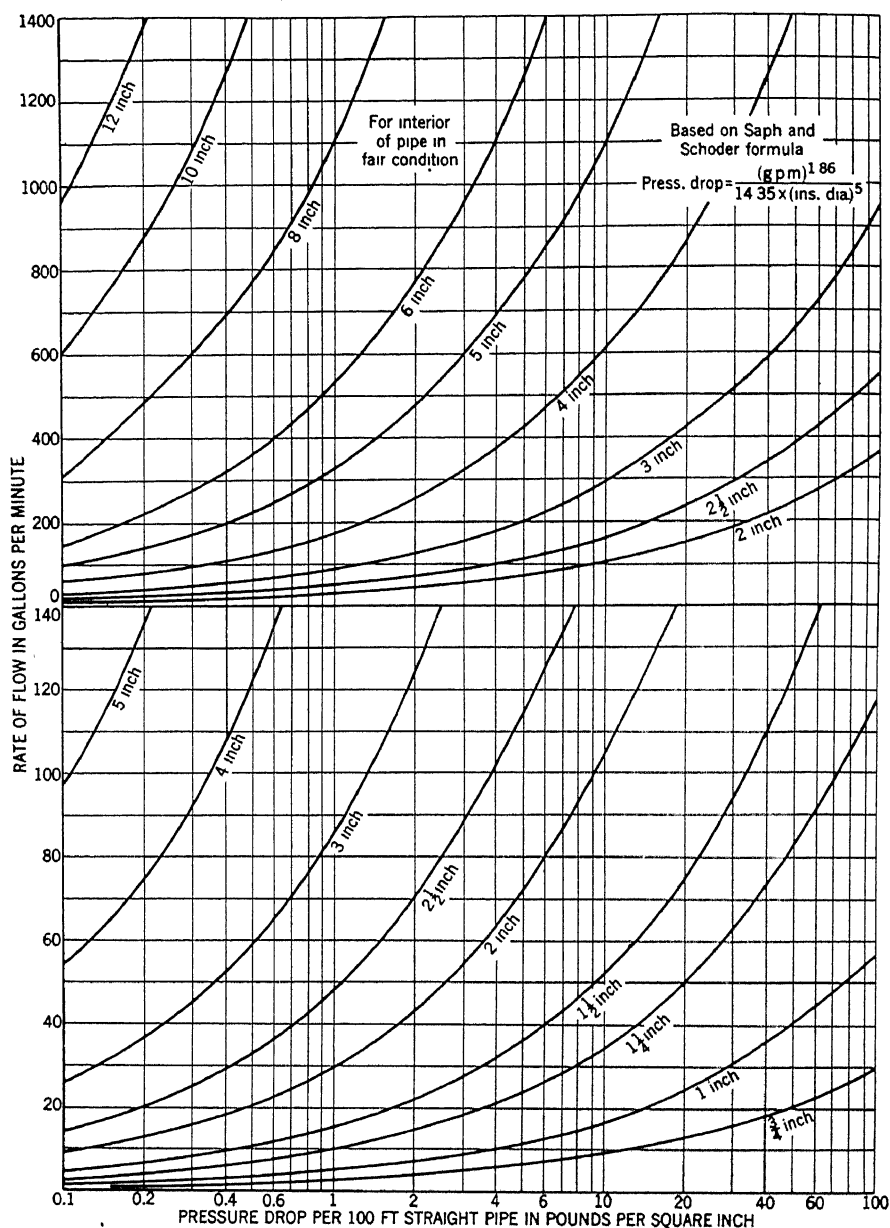


FIG. 2. CHART GIVING PRESSURE DROP FOR VARIOUS RATES OF FLOW OF WATER

should always be used to recheck the exact equivalent length of the pipe after an approximate diameter has been selected and after the number of fittings has been determined. The allowable pressure drop per 100 ft of

pipe may be determined by dividing the total allowable drop for the system by the equivalent length of the system in hundreds of feet.

The pressure drop for various rates of water flow for standard size pipes is given in Fig. 2. This chart carries an allowance for reasonable roughness of the interior surface and for the effect of many years of service. The Saph and Schoder formulae have been proved conservative not only by the *American Water Works Association* but also by various tests conducted by the A.S.H.V.E. Committee on Research.

Example 2. Assume a street pressure of 70 lb, the height of the highest fixture 50 ft, the length of the longest run 200 ft, the pressure at the top fixture 15 lb, and the pressure loss through the meter 10 lb. Without knowing the additional length of pipe to be added for the fittings it will be assumed that this is about 100 ft. The surplus pressure

TABLE 3. APPROXIMATE ALLOWANCES FOR FITTINGS AND VALVES IN FEET OF STRAIGHT PIPE

SIZE OF PIPE (INCHES)	TYPE OF FITTING OR VALVE					
	90 DEG ELBOW	45 DEG ELBOW	TEE IN RUN OF MAIN	GATE VALVE	GLOBE VALVE	ANGLE VALVE
1/2	2	1	1	1	17	9
3/4	2	1	2	1	21	12
1	3	1	2	1	29	15
1 1/4	4	2	3	1	38	19
1 1/2	5	2	3	1	45	22
2	5	3	3	1	58	28
2 1/2	7	3	5	2	68	34
3	8	4	6	2	82	42
4	11	5	7	2	115	56
5	14	6	9	3	140	70
6	16	8	11	4	160	85

which will be available for pressure drop will then be 70 lb - (15 lb + 10 lb + 50 ft × 0.43 lb) = 70 lb - (15 lb + 10 lb + 21.5 lb) = 23.5 lb.

To change this into drop per 100 ft: $\frac{23.5 \text{ lb} \times 100}{200 \text{ ft} + 100 \text{ ft}} = 7.8 \text{ lb per 100 ft.}$

The pipe may then be sized from the probable flow by selecting a size that does not give a drop in excess of 7.8 lb per 100 ft.

METHOD OF SIZING UP-FEED SYSTEMS

Example 3. A typical layout of cold water lines for a 3-story, nine-family apartment house is shown in Fig. 3. The branch to each apartment supplies 1 lavatory, 1 bath tub, 1 flush valve closet, and 1 kitchen sink. Pressure in the street main is 70 lb per square inch and a minimum pressure of 15 lb per square inch must be maintained on the top floor. Find the sizes of all parts of the system.

Solution: The first step toward the solution of such a problem is the determination of the probable flow in the various parts of the system. In Section 4, which supplies cold water to a single apartment, the maximum flow would be as follows:

1 water closet.....	45 gpm
1 lavatory.....	3 gpm
1 tub.....	5 gpm
1 sink.....	4 gpm
	<hr/> 57 gpm

From Fig. 1, the probable usage for 57 gpm maximum flow in a mixed system is 100 per cent. Therefore, Section A should be sized for 57 gpm.

Section B, which supplies two apartments will have a maximum flow of 2×57 gpm = 114 gpm. From Fig. 1, the probable usage for 114 gpm is approximately 75 per cent and the probable flow in Section B = $114 \times 0.75 = 86$ gpm.

Similarly, the probable flow in Section C is found to be 98 gpm. Since all risers in this particular example are supplying the same number of fixtures, the probable flow in risers 1 and 2 is the same as determined for riser 3.

To determine the probable flow in Section E, add the maximum flow in risers 2 and 3, and multiply the sum by the probable usage for the sum, thus: $(171 + 171) \times 0.35 = 120$ gpm probable flow in E. Similarly, the probable flow in Section F is determined.

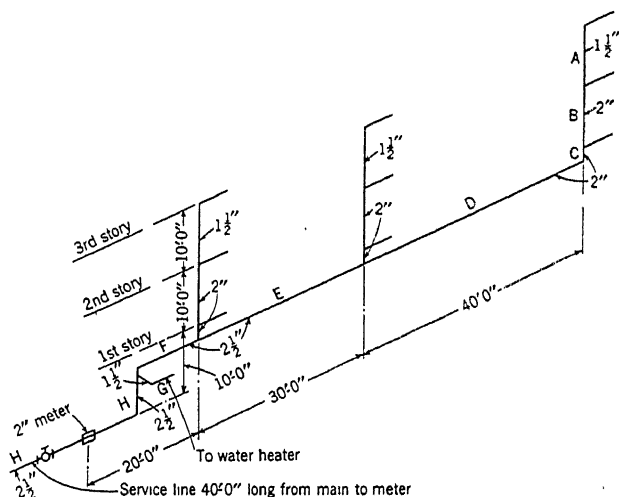


FIG. 3. UP-FEED COLD WATER SYSTEM WITH FLUSH VALVES

It should be noted that the probable flow in E cannot be determined by adding the probable flow in risers 2 and 3.

To determine the maximum flow in line G to the water heater, the total hot water requirements are determined as follows:

9 laboratories.....	9 × 3 = 27 gpm
9 tubs.....	9 × 5 = 45 gpm
9 sinks.....	9 × 4 = 36 gpm
Maximum flow.....	= 108 gpm

The probable flow in all sections of the system are determined as described previously, and tabulated in Table 4.

The next step in the solution is the determination of the allowable pressure drop:

Loss in a 2 in. meter for 149 gpm, from Table 2	= 22 lb per square inch
Hydrostatic head = 30 ft (30×0.43).....	= 13 lb per square inch
Pressure at top fixture.....	= 15 lb per square inch
Total.....	50 lb per square inch
Allowable pressure loss = 70 - 50 lb.....	= 20 lb per square inch

To determine the allowable pressure loss per 100 ft of pipe, the longest run to the highest fixture must be used. In Fig. 3 this would be the length to the top fixtures on riser No. 3. The developed length from the meter to the top of riser 3 is 120 ft, and the

equivalent length, allowing 50 per cent for fittings is 180 ft. The service line is 40 ft long, making a total equivalent length of 220 ft from the main to the farthest fixture. Since the service line is usually straight, no allowance has been made for fittings.

The total allowable loss is 20 lb per square inch, and the developed length of piping is 220 ft. Therefore, the allowable loss per 100 ft of pipe is $\frac{20 \times 100}{220} = 9.1$ lb.

Knowing the probable flow in all lines and the allowable loss per 100 ft of pipe, it is possible to determine the pipe sizes from Fig. 2 by reading the pipe size indicated at the intersection of the two known factors. Pipe sizes for all parts of the system are given in Table 4.

Ordinarily the size above the intersection on the chart is selected. However, it is permissible to select a pipe slightly undersize if the next section of the line is oversize. This is illustrated in the sizing of sections *A* and *B*. The pipe size of 1½ in. is slightly small for *A*, but 2 in. is enough oversize for *B*, so that the average loss in the two is less than 9.1 lb per 100 ft.

In this example, all risers have been sized for the same loss per 100 ft of pipe. Where the main is long it is frequently possible to increase the pressure drop per 100 ft of pipe in the risers near the meter, and thus reduce their size. For example, the total friction

TABLE 4. SUMMARY OF RESULTS FOR EXAMPLE 3

SECTION	MAXIMUM FLOW GPM	PROBABLE USAGE PER CENT	PROBABLE FLOW GPM	ALLOWABLE LOSS LB PER 100 FT	PIPE SIZE IN.
A	57	100	57	9.1	1½
B	114	75	86	9.1	2
C-D	171	57	98	9.1	2
E	342	36	123	9.1	2½
F	513	28	144	9.1	2½
G	108	43 ^a	46	9.1	1½
H	621	24	149	9.1	2½

^aFrom curve for fixtures having no flush valves.

loss from the meter to the top of riser 1 in Fig. 3, could be as great as the total loss from the meter to the top of riser 3. However, all parts of the main must always be sized to assure sufficient pressure at the last riser. In a small system, such as shown in Fig. 3, no appreciable reduction in pipe sizes can be made by taking advantage of the possibility just described.

PIPE SIZES FOR DOWN-FEED COLD WATER SYSTEM

The risers for down-feed systems may be reduced considerably in size compared with those for up-feed systems because of the 0.43 lb per foot gain in pressure due to increasing hydrostatic head as the lowest story is approached. It has proved practicable to select down-feed riser sizes on the basis of a pressure drop of 30 lb per 100 ft. The 13 lb difference between 43 lb per 100 ft and 30 lb per 100 ft will usually take care of the friction in the fittings.

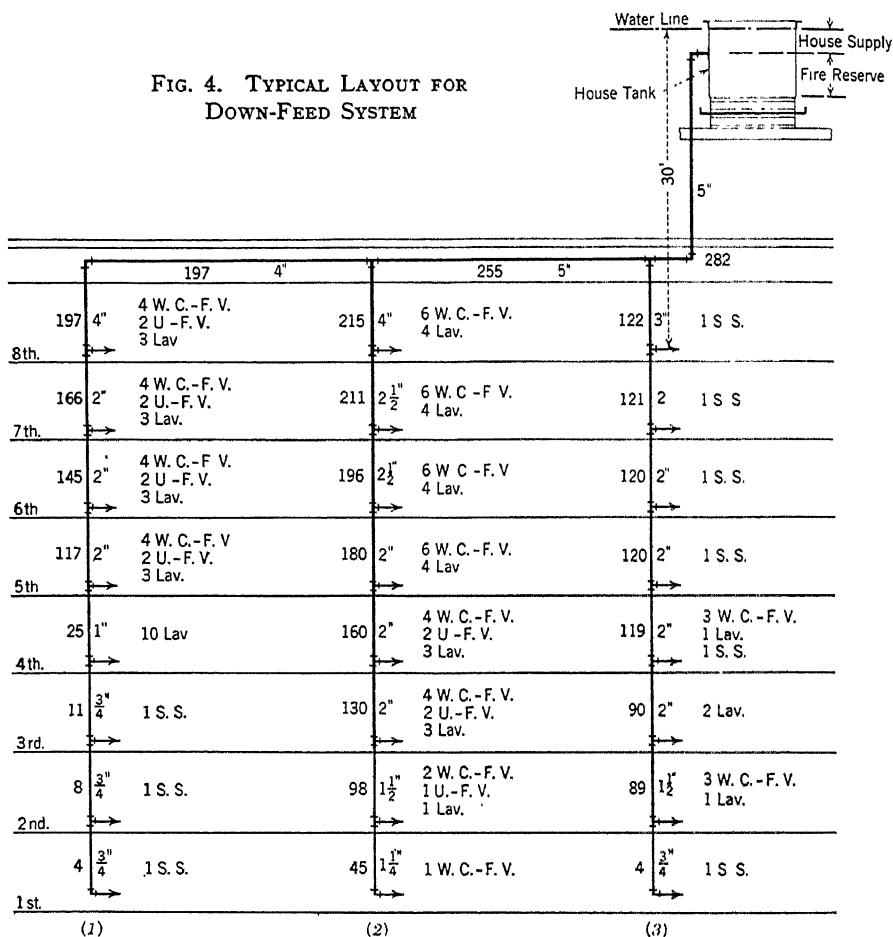
The overhead mains, however, must be selected conservatively, as the pressure at the top will be low and the pressure drop available for friction will necessarily be small. In nearly all tall buildings the pressure is limited to that due to the hydrostatic head between the house tank and the main, though sometimes this is increased by the use of a pneumatic house tank.

Where flush valves are used on top story closets the minimum practic-

able difference in elevation between the overhead mains and the bottom of an open type house tank is 20 ft, and flush valves specially adapted to operate on about 7 lb pressure must be used. In many installations gravity tank closets are used on the top story.

Example 4. Suppose an installation has a house tank in which the water line is 20 ft above the level of the top fixtures to be supplied and that the length of run to the farthest fixtures on this level is 400 ft with the pipe fittings adding another 200 ft, making an

FIG. 4. TYPICAL LAYOUT FOR
DOWN-FEED SYSTEM



equivalent length of 600 ft. What would be the size of main coming out of the tank where a probable flow rate of 400 gpm may be expected, of the horizontal main where a probable flow rate of 200 gpm may be expected, and of the riser down to the fixture level where the probable flow rate is approximately 100 gpm?

Here the level of the water in the house tank is 20 ft above the faucet of the highest fixture and the gravity pressure will be $0.43 \text{ lb} \times 20 \text{ ft} = 8.6 \text{ lb}$ and, if a total pressure drop of 1 lb is assumed, the pressure on the farthest fixture under times of peak load will be $8.6 \text{ lb} - 1 \text{ lb} = 7.6 \text{ lb}$ while the drop per 100 ft of equivalent run will have to be $\frac{1 \text{ lb} \times 100}{600} = 0.1667 \text{ lb}$.

CHAPTER 46. WATER SUPPLY PIPING AND WATER HEATING

Referring to Fig. 2 it will be noted that where the flow through the main is 400 gpm, an 8-in. pipe would be required; that where the flow is reduced to 200 gpm, a 6-in. pipe would be sufficient; and that where the flow is 100 gpm in the riser branch and riser, a 5-in. size would be correct. Of course these are somewhat excessive flows and the head from the tank is small so that large sizes are to be expected. It would be necessary to carry a 5-in. riser down to the branch of the top floor, then reduce to 4 in. for the branch to the floor below the top, and below this the pipes could be sized for a 30 lb drop per 100 ft. In such a case, tank closets should doubtless be used on the top floor.

Had the tank been set 10 ft higher, the head available for friction, while still giving the same pressure at the top fixtures, would have been $0.43 \text{ lb} \times 10 \text{ ft}$ or 4.3 lb greater and this, with the 1 lb drop used previously, would give a total allowable drop of 1 lb

TABLE 5. TYPICAL CALCULATION OF PIPE SIZES ON DOWN-FEED RISER WITH FLUSH VALVE WATER-CLOSETS AND URINALS

(Riser No. 1. Fig. 4)

FLOOR OF BLDG.	FIXTURES ON FLOOR	GPM PER FIXTURE	MAXIMUM GPM ON FLOOR	MAXIMUM GPM ON RISER	USAGE (PER CENT)	PROBABLE FLOW IN RISER GPM	ALLOWABLE DROP LB PER 100 FT	PIPE SIZE IN.
1st	1 S. S.	4	4	4	100	4	30	$\frac{3}{4}$
2nd	1 S. S.	4	4	8	100	8	30	$\frac{3}{4}$
3rd	1 S. S.	4	4	12	92	11	30	$\frac{3}{4}$
4th	10 Lav.	3	30	42	58	25	30	1
5th	4 W. C. 2 U. 3 Lav.	45 30 3	180 60 9					
			249	291	40	117	30	2
6th	4 W. C. 2 U. 3 Lav.	45 30 3	180 60 9					
			249	540	27	145	30	2
7th	4 W. C. 2 U. 3 Lav.	45 30 3	180 60 9					
			249	789	21	166	30	2
8th	4 W. C. 2 U. 3 Lav.	45 30 3	180 60 9					
			249	1038	19	197	2	4

+ 4.3 lb = 5.3 lb which, divided by the 600 ft equivalent run gives a drop per 100 ft of $\frac{5.3 \times 100}{600} = 0.9 \text{ lb}$.

With this drop, the sizes according to the chart (Fig. 2) are 6 in., 5 in., and 4 in., respectively. If the run is reduced to 200 ft instead of 600 ft, the allowable drop will be $\frac{5.3 \text{ lb} \times 100}{200} = 2.7 \text{ lb per 100 ft}$. This gives 5 in., 4 in., and 3 in., respectively, for the flows of 400, 200, and 100 gpm.

From Example 4 it is evident that, while the down-feed system possesses certain economies in size for the riser portion, it is quite likely to involve large distribution main sizes, especially when the tank is not elevated to a considerable degree.

Example 5. Fig. 4 shows a typical down-feed layout with three risers extending eight stories and with the fixtures noted on each floor. This will be solved assuming that the level of the water in the house tank is 30 ft above the fixtures on the top floor, that the length of run from the tank to the farthest fixture is 200 ft, equivalent length of fittings 100 ft, and the pressure required at the fixture is 7 lb.

The 30-ft head is equal to a static pressure of 0.43×30 or 12.9 lb per square inch and to maintain a pressure of 7 lb at the highest fixtures the drop allowable in pressure is $12.9 - 7.0$ lb or 5.9 lb. As the total equivalent run is 300 ft, this is a drop per 100 ft of 1.97 lb, or practically 2 lb. Therefore, all risers and mains from the top floor back to the tank must be sized on the basis of a drop of 2 lb per 100 ft. Tables 5, 6, 7 and 8 show the schedule for Risers Nos. 1, 2 and 3 with the maximum flow taken from Table 1, the percentage of use at the peak taken from Fig. 1, and the probable flow at the peak worked out for each portion of the riser. Riser sizes are taken from Fig. 2, using a drop of 30 lb per 100 ft except on the riser from the top story back to the tank where 2 lb per 100 ft is the allowable limit.

Since down-feed risers are nearly always sized for a pressure loss of 30 lb per 100 ft, it is possible to arrange useful sizing data in tabular form. Fig. 5 shows a typical down-feed riser for a 20 story building. Table 9 may be used for sizing such a riser of any height and for any probable flow up to 250 gpm.

TABLE 6. TYPICAL CALCULATION OF PIPE SIZES ON DOWN-FEED RISER WITH FLUSH VALVE WATER-CLOSETS AND URINALS

(Riser No. 2. Fig. 4)

FLOOR OF BLDG.	FIXTURES ON FLOOR	GPM PER FIXTURE	MAXIMUM GPM ON FLOOR	MAXIMUM GPM ON RISER	USAGE (PER CENT)	PROBABLE FLOW IN RISER GPM	ALLOWABLE DROP LB PER 100 FT	PIPE SIZE IN.
1st	1 W. C.	45	45	45	100	45	30	1½
2nd	2 W. C. 1 U. 1 Lav.	45 30 3	90 30 3 <hr/> 123	168	58	98	30	1½
3rd	4 W. C. 2 U. 3 Lav.	45 30 3	180 60 9 <hr/> 249	417	31	130	30	2
4th	4 W. C. 2 U. 3 Lav.	45 30 3	180 60 9 <hr/> 249	666	24	160	30	2
5th	6 W. C. 4 Lav.	45 3	270 12 <hr/> 282	948	19	180	30	2
6th	6 W. C. 4 Lav.	45 3	270 12 <hr/> 282	1230	16	196	30	2½
7th	6 W. C. 4 Lav.	45 3	270 12 <hr/> 282	1512	14	211	30	2½
8th	6 W. C. 4 Lav.	45 3	270 12 <hr/> 282	1794	12	215	2	4

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TABLE 7. TYPICAL CALCULATION OF PIPE SIZES ON DOWN-FEED RISER WITH FLUSH VALVE WATER-CLOSETS AND URINALS

(Riser No. 3. Fig. 4)

FLOOR OF BLDG.	FIXTURES ON FLOOR	GPM PER FIXTURE	MAXIMUM GPM ON FLOOR	MAXIMUM GPM ON RISER	USAGE (PER CENT)	PROBABLE FLOW IN RISER GPM	ALLOWABLE DROP LB PER 100 FT	PIPE SIZE IN.
1st	1 S. S.	4	4	4	100	4	30	$\frac{3}{4}$
2nd	3 W. C. 1 Lav.	45 3	135 3 <hr/> 138	142	63	89	30	$1\frac{1}{2}$
3rd	2 Lav.	3	6	148	61	90	30	$1\frac{1}{2}$
4th	3 W. C. 1 Lav. 1 S. S.	45 3 4	135 3 4 <hr/> 142	290	41	119	30	2
5th	1 S. S.	4	4	294	41	120	30	2
6th	1 S. S.	4	4	298	40	120	30	2
7th	1 S. S.	4	4	302	40	121	30	2
8th	1 S. S.	4	4	306	40	122	2	3

TABLE 8. SIZE OF DISTRIBUTION MAIN FOR DOWN-FEED SYSTEMS (SEE FIG. 4)

RISER No.	MAXIMUM GPM RISER	MAXIMUM GPM MAIN	USAGE (PER CENT)	PROBABLE GPM	ALLOWABLE DROP LB PER 100 FT	SIZE OF MAIN IN.
1	1038	1038	18	187	2	4
2	1794	2832	9	255	2	4
3	306	3138	9	282	2	5

It should be noted that the two top floors in Fig. 5 are sized for less than 30 lb per 100 ft. Regardless of the height of the riser being sized, the two top floors of it should be sized from values given for the top floors of Fig. 5.

HOT WATER SUPPLY PIPING

The same basic principles used in the design of cold water piping are also applicable to hot water systems. Hot water, like cold water, may be distributed by either up-feed or down-feed systems.

It is common practice to provide circulation in a hot water supply system so that hot water may be quickly available when the faucet is opened. If this is not done, it is necessary to drain all of the cold water from the lines between the faucet and the heater, before hot water can be obtained.

Three common methods of arranging hot water circulating lines are illustrated in Fig. 6. Although the diagrams are for multi-story buildings, arrangements *a* and *b* are also used frequently in residences.

A check valve should be provided in the runout from each return riser to prevent temporary reversal of flow in the line when a faucet is opened.

Proper air venting of a circulated system is extremely important, particularly if gravity circulation is employed. In Fig. 6a and 6b this is

TABLE 9. SCHEDULE OF SIZES FOR DOWN-FEED RISER (SEE FIG. 5)

PORTION OF RISER	ALLOWABLE DROP PER LB PER 100 FT	PROBABLE FLOW, GALLONS PER MINUTE																		
		5	10	15	20	25	30	40	50	60	70	80	90	100	125	150	200	250		
		T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B
3.5	3/4	1	1 1/4	1 1/4	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2	2 1/2	3	3	3	3 1/2	3 1/2	3		
20	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/2	1 1/2	2	2	2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
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30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
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30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2	2 1/2
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30	3/4	3/4	3/4	1	1	1	1	1 1/4	1 1/4											

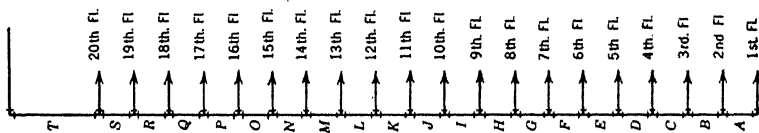


FIG. 5. TYPICAL RISER FOR 20-STORY BUILDING

accomplished by connecting the circulating line below the top fixture supply. Air is thus eliminated from the system each time the top fixture is opened. Where an overhead main is located above the highest fixture,

as in Fig. 6c an automatic float type air vent is installed at the highest point of the system or a fixture branch is taken off the top of the main where air venting is desired and then dropped down to the fixture outlet.

The supply riser in Fig. 6a would be sized exactly the same as an up-feed cold water riser. The sizing of Fig. 6b and 6c would involve calculations for both up-feed and down-feed risers. Pressure loss in the overhead main would have to be considered in sizing the up-feed risers.

The return line for a gravity circulating system should never be less than $\frac{3}{4}$ in. Where supply risers are large or lines are long, larger circulating lines may be indicated. Pumps are frequently used in large systems to provide positive circulation.

It is sometimes necessary to make an allowance for pressure drop in the

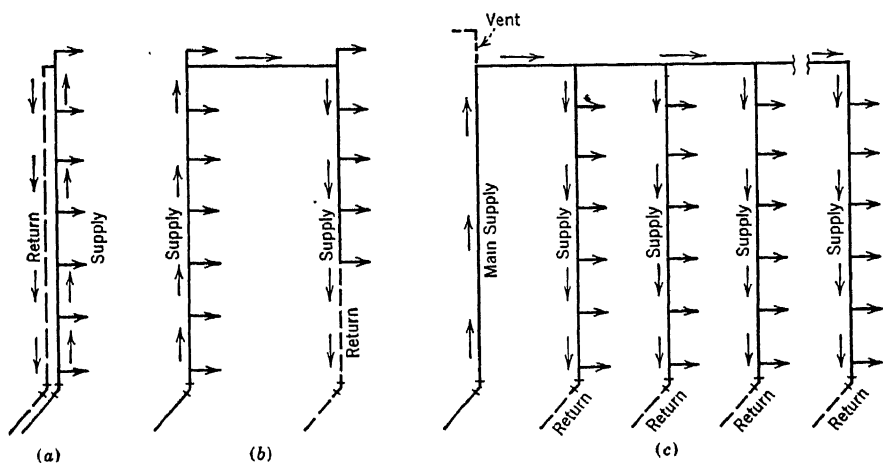


FIG. 6. METHODS OF ARRANGING HOT WATER CIRCULATION LINES

heater when sizing hot water lines. This is particularly true where instantaneous heaters are used.

STORAGE CAPACITY AND HEATING LOAD

In estimating the size of hot water storage tank required and the heating capacity to be provided either from the boiler or from an independent domestic hot water heater, it is necessary to know the total quantity of water to be heated per day, and the maximum amount which will be used in any one hour, as well as the duration of the peak load.

In cases where the requirements for hot water are reasonably uniform, as in residences, apartment buildings, hotels, and the like, smaller storage capacity is required than in the case of factories, schools, office buildings, etc., where practically the entire day's usage of hot water occurs during a very short period. Correspondingly, the heating capacity must be proportionately greater with uniform usage of hot water than with intermittent usage where there may be several hours between peak demands during which the water in the storage tank can be brought up to temperature. As a general rule it is desirable to have a large storage capacity in

order that the heating capacity and consequently the size of the heater, or the load on the heating boiler may be as small as possible.

In estimating the hot water which can be drawn from a storage tank it should be borne in mind that only about 75 per cent of the volume of the tank is available, as by the time this quantity has been drawn off the incoming cold water has cooled the remainder down to a point where it can no longer be considered hot water.

Where steam from the heating boiler is used to heat domestic hot water, the computed load on the boiler should be increased by 4 sq ft EDR (equivalent direct radiation) for every gallon of water per hour heated through a 100 F rise. The actual requirement is $\frac{100 \times 8.33}{240} = 3.48$ sq ft per gallon of water heated 100 F. The value of 4 allows for transmission losses, etc.

There are two ways in common use of estimating the hot water requirements of a building; first, by the number of people and second, by the number of plumbing fixtures installed. Where the number of people to be served is known or can be reasonably estimated, the data in Table 10 may be used.

Example 6. From Table 10, a residence housing five people would have a daily requirement of $5 \times 40 = 200$ gal per day, and a maximum hourly demand of $200 \times \frac{1}{4} = 28.5$ gal. The heater should have a storage capacity of $200 \times \frac{1}{5} = 40$ gal and a heating capacity of $200 \times \frac{1}{4} = 28.5$ gal per hour.

The conditions given in Example 6 may be cited as average. It is possible to vary the storage and heating capacity by increasing and

TABLE 10. ESTIMATED HOT WATER DEMAND PER PERSON FOR VARIOUS TYPES OF BUILDINGS

TYPE OF BUILDING	HOT WATER REQUIRED AT 140 F	MAX. HOURLY DEMAND IN RELATION TO DAY'S USE	DURATION OF PEAK LOAD HOURS	STORAGE CAPACITY IN RELATION TO DAY'S USE	HEATING CAPACITY IN RELATION TO DAY'S USE
Res., apts., hotels, etc.	40 gal per person per day	$\frac{1}{4}$	4	$\frac{1}{5}$	$\frac{1}{4}$
Office buildings	2 gal per person per day	$\frac{1}{5}$	2	$\frac{1}{5}$	$\frac{1}{6}$
Factory buildings	5 gal per person per day	$\frac{1}{3}$	1	$\frac{2}{5}$	$\frac{1}{8}$
Restaurants \$0.50 meals \$1.00 meals \$1.50 meals	1.5 gal per meal 2.5 gal per meal 4.5 gal per meal			$\frac{1}{10}$	$\frac{1}{10}$
Restaurants 3 meals per day		$\frac{1}{10}$	8	$\frac{1}{5}$	$\frac{1}{10}$
Restaurants 1 meal per day		$\frac{1}{5}$	2	$\frac{2}{5}$	$\frac{1}{6}$

CHAPTER 46. WATER SUPPLY PIPING AND WATER HEATING

TABLE 11. HOT WATER DEMAND PER FIXTURE FOR VARIOUS TYPES OF BUILDINGS
Gallons of water per hour per fixture, calculated at a final temperature of 140 F

	APART- MENT HOUSE	CLUB	GYM- NASIUM	HOS- PITAL	HOTEL	INDUS- TRIAL PLANT	OFFICE BUILD- ING	PRIVATE RESI- DENCE	SCHOOL	Y.M. C.A.
Basins, private lavatory ..	2	2	2	2	2	2	2	2	2	2
Basins, public lavatory ..	4	6	8	6	8	12	6	....	15	8
Bathtubs	20	20	30	20	20	30	..	20	...	30
Dishwashers .. .	15	50-150	..	50-150	50-200	20-100	..	15	20-100	20-100
Foot basins	3	3	12	3	3	12	.	3	3	12
Kitchen sink	10	20		20	20	20	.	10	10	20
Laundry, stationary tubs	20	28		28	28	..	..	20	..	28
Pantry sink	5	10		10	10	..	....	5	10	10
Showers	75	150	225	75	75	225	..	75	225	225
Slop sink	20	20	..	20	30	20	15	15	20	20
Hourly heating capacity factor	30%	30%	40%	25%	25%	40%	30%	30%	40%	40%
Storage capacity factor ¹	125%	90%	100%	60%	80%	100%	200%	70%	100%	100%

decreasing one over the other. Such a condition is illustrated in Example 7.

Example 7. Assume an apartment house housing 200 people. From the data in Table 10: Daily requirements = $200 \times 40 = 8000$ gal. Maximum hours demand = $8000 \times \frac{1}{4} = 1140$ gal. Duration of peak load = 4 hours. Water required for 4-hour peak = $4 \times 1140 = 4560$.

If a 1000 gal storage tank is used, hot water available from the tank = $1000 \times 0.75 = 750$. Water to be heated in 4 hours = $4560 - 750 = 3710$ gal. Heating capacity per hour = $\frac{3710}{4} = 930$ gal.

If instead of a 1000 gal tank, a 2500 gal tank had been installed, the required heating capacity per hour would be $\frac{4560 - (2500 \times 0.75)}{4} = 671$ gal.

In cases where the number of fixtures only are known, the data in Table 11 have been found satisfactory.

Example 8. An apartment building has a hot water requirement as follows:

60 lavatories.....	$\times 2 =$	120 gal per hour
30 bath tubs.....	$\times 20 =$	600 gal per hour
30 showers.....	$\times 75 =$	2250 gal per hour
60 kitchen sinks.....	$\times 10 =$	600 gal per hour
15 laundry tubs.....	$\times 20 =$	300 gal per hour

Maximum hourly requirement.....	=	3870 gal per hour
Hourly heating capacity.....	= 3870×0.30	= 1161 gal per hour
Storage capacity.....	= 1161×1.25	= 1450 gal per hour

METHODS OF HEATING WATER

Hot water may be heated either by the direct combustion of fuel, by an intermediate carrier such as steam or hot water, or by electrically heated

surfaces. The simplest method is to have the fire on one side of a metal barrier and water on the other. In such a method if the water surfaces of heat transfer are small, and if the water carries a heavy proportion of precipitable salts, the water passages may soon clog and then burn out. A familiar example of such trouble is the water back of the firebox in the kitchen stove or the pipe coil inserted into the firebox of a warm air furnace or small boiler. The critical water temperature at which the lime, magnesia, etc. collect on hot surfaces, varies with the character and proportions of the solids, but generally such deposits are not a serious trouble with water temperatures lower than 140 F.

Coal burning direct-fired water heaters are either of cored-out cast-iron, with water entirely surrounding the combustion chamber, or of steel with water tubes which in some cases form racks to suspend garbage above the fire. These heaters are generally so small that low temperature com-

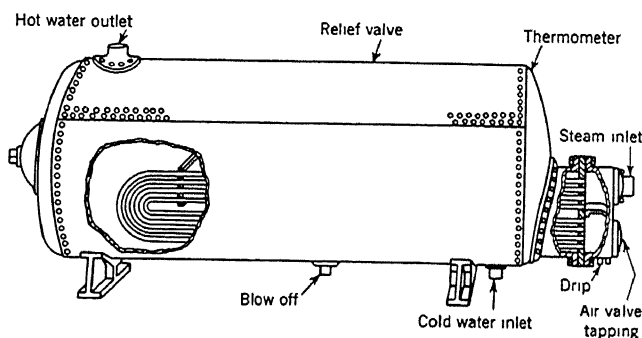


FIG. 7. INDIRECT WATER HEATER

bustion at poor efficiency ensues. Mud and scale may eventually close the water ways.

Oil burning direct-fired water heaters usually are of steel and operate with higher flame temperature and better efficiency than commensurate sized coal burning heaters. They have the same tendency as coal boilers to *lime up*, and the water passages should be large in cross-section and accessible for periodic cleaning.

Gas burning water heaters may be of the water-tube type having spiral copper tubes or of the instantaneous type used without a storage tank.

In the indirect method either steam or hot water is used for heating the water. With steam the water to be heated is preferably circulated around the outside of the steam tubes which are submerged within a tank. A typical indirect heater using steam is shown in Fig. 7. The coils usually are of copper and are U shaped to permit expansion and contraction. The shell may be of steel, copper or with a special inside protective lining. Where straight heating tubes are used, one end of the tube is usually expanded into a *floating* head to take care of expansion. The coils should be capable of easy withdrawal for inspection and for removal of scale. Instead of steam the heating medium may also be hot water inside the tubes.

Another method of transferring heat from a heating boiler to the

domestic water is illustrated in Fig. 8. The water heater is generally a cast-iron shell within which there is located a spiral copper coil. Hot water from the boiler circulates inside the shell and around the coil and returns to the boiler, while domestic water from the storage tank circulates inside the coil. The storage tank should be installed with the bottom of the tank as far above the boiler as possible. Horizontal storage tanks smaller than 18 or 20 in. diameter are not recommended because of the difficulty of preventing the hot and cold water from mixing, and especially is this an important consideration when large quantities of water are withdrawn. In Fig. 9 the heat transfer surface is placed inside the boiler instead of in a separate vessel, but otherwise the operation is similar to that of Fig. 8. This arrangement with vertical tank is commonly used for small domestic installations.

Sometimes the heating element is located inside of the larger type fire tube boilers. In this case the heat transfer surface is in the form of a

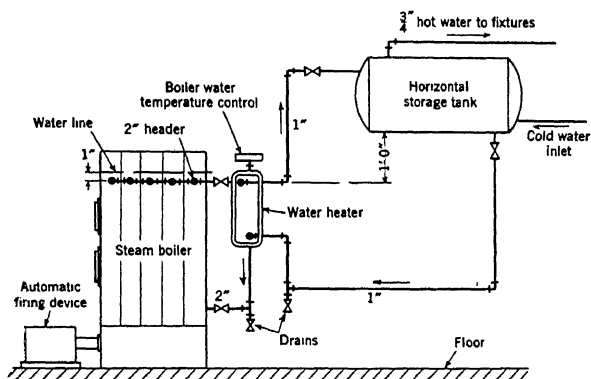


FIG. 8. INDIRECT WATER HEATER MOUNTED ON SIDE OF BOILER

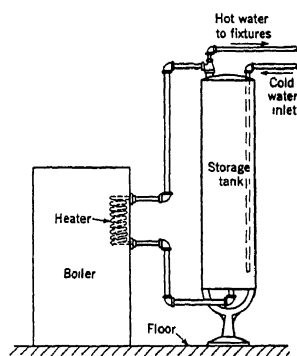


FIG. 9. INDIRECT WATER HEATER PLACED IN BOILER

number of straight copper tubes with rear *U* bends or a floating head, inserted through the front head of the boiler. While the coil may be located in the steam space above the water line of a steam boiler, it operates more satisfactorily when below the water line since clogging of the water tubes may thereby be delayed. This method is widely used without storage tanks since the intimate contact and efficient circulation of the water in this arrangement permits the utilization of the heat stored in the water of the boiler. A thermostatic three-way mixing valve is used to maintain a uniform temperature of the hot water going to the plumbing fixtures.

In order to reduce clogging by precipitated solids, water heating plants sometimes develop steam in a closed circuit, transferring the heat through a tubular heater to the domestic water. The water in the primary heater, exposed to the high temperature of the fire is repeatedly used and hence has no appreciable tendency to deposit scale, while the domestic water, heated by steam at a much lower temperature than that of the fire, also exhibits a much reduced tendency to separate its dissolved salts.

COMPUTING AREA OF HEAT TRANSMITTING SURFACE

The area of the inside surface of a heating coil may be determined from Equation 1.

$$A = \frac{Q \times 8.33 (t_2 - t_1)}{K_o \times t_m} \quad (1)$$

where

A = surface area of coil, square feet.

Q = quantity of water heated, gallons per hour.

t_2 = hot water outlet temperature, degrees Fahrenheit.

t_1 = cold water inlet temperature, degrees Fahrenheit.

K_o = coefficient of heat transmission, Btu per hour per square foot surface.

For copper or brass coils $K_o = 240$ (steam) and 100 (hot water).

For iron coils $K_o = 160$ (steam) and 67 (hot water).

t_m = logarithmic mean of the difference between the temperature of the heating medium and the average water temperature. t_m is approximately =

$$t_s - \left[\frac{(t_o + t_i)}{2} \right]$$

t_s = temperature of the coil surface, degrees Fahrenheit.

Equation 1 may be used to check the heating coil ratings under temperature conditions differing from those stated in the manufacturer's published ratings.

Example 9. What area of copper transfer surface will be required to heat 70 gal per hour from 40 to 180 F with boiler water at 220 F?

$$t_m = \left[220 - \frac{(180 + 40)}{2} \right] = 110$$

$$A = \frac{70 \times 8.33 (180 - 40)}{100 \times 110} = 7.39 \text{ sq ft.}$$

The rate of heat transfer between steam or water as the carrier and the domestic water is influenced by the rate of movement of both the carrier and the water which receives the heat. For this reason, where the transfer is from heating system water to domestic water, it is good practice to install a circulating pump to insure rapid movement of the boiler water.

In view of the high condensation rates when steam is used with gravity circulation from the boiler and when there is a sudden demand followed by an inflow of cold water, the bottom of a steam heating transfer element always should be at least 30 in. above the boiler water line, and the steam and condensate return pipes should be of liberal size. Otherwise water hammer and reduced capacity may result due to imperfect drainage of condensate.

When connecting a transfer-type hot water heater below the water line of a cast-iron steam boiler having vertical sections, there should be a separate tapping for water circulation into every section of the boiler, as shown in Fig. 8. Ordinarily in steam boilers of this type the top connecting nipples between the sections are in the steam space and thus no full internal circulation of water can occur. If a connection to any section is omitted, steaming may take place in that section during summer opera-

tion when steam generation is undesirable. Water heating capacity would also be reduced.

COMPUTING GRATE AREA FOR COAL-FIRED HEATER

The grate area required for a small coal-fired water heater may be calculated by Equation 2.

$$G = \frac{W (t_2 - t_1) \times 100}{H \times E \times C} \quad (2)$$

where

G = grate area, square feet.

W = weight of water, pounds per hour.

$t_2 - t_1$ = temperature difference between entering and leaving water, degrees Fahrenheit.

H = heating value of coal, Btu per pound.

C = weight of coal burned, pounds per hour per square foot of grate.

E = efficiency, per cent.

In a small heater 4.5 lb is a conservative value for C , and an efficiency of 60 per cent would represent excellent performance.

Example 10. What grate area is required for a coal-burning water heater warming 100 gal per hour of water from 50 to 180 F, when the combustion rate is 4.5 lb per hour per square foot of grate, if the heating value of the fuel is 12,500 Btu per pound, and the efficiency is 60 per cent?

$$\text{Substituting: } G = \frac{100 \times 8.3 \times (180 - 50) \times 100}{12,500 \times 60 \times 4.5} = 3.2 \text{ sq ft.}$$

The quantity of gas, oil, or other fuel required per hour for water heating may be calculated by Equation 3.

$$F = \frac{W (t_2 - t_1) \times 100}{H \times E} \quad (3)$$

where

F = units of fuel (lb, cu ft, gal, etc).

H = heating value of fuel, Btu per unit.

W = weight of water, pounds per hour.

$t_2 - t_1$ = temperature difference between entering and leaving water, degrees Fahrenheit.

E = efficiency, per cent.

Efficiencies for oil and gas may be taken as 75 and 80 per cent respectively. The heating value of the fuel and the temperature rise should be determined to suit local conditions.

CONTROL OF SERVICE WATER TEMPERATURE

Coal-fired boilers are usually controlled by an aquastat located in the heated water, which opens or closes draft dampers at the boiler to adjust the rate of fuel combustion. With oil- or gas-fired boilers the aquastat controls the oil burner motor or the magnetic gas valve. The gas pilot flame usually burns continuously. With electric heaters the aquastat operates a switch on the source of energy.

When steam or hot water is the medium for heating the water in the

tank, the aquastat controls a valve in the steam or hot water supply line. In small residence installations using water as the carrier a combined aquastat and butterfly valve all in one simple fitting may be installed in the transmitting circuit to prevent overheating of the service water.

In residences heated by pump circulated hot water, the house temperature is controlled by operating the circulating pump intermittently, while domestic hot water is warmed by transfer from the house boiler, independent of the pump operation. The domestic water is heated from the heating boiler the year around. Under such an arrangement, to prevent overheating the house by thermal circulation when the pump is not running, it is usual to insert a weighted check-valve in the house heating main, so that no circulation to the house heating system can occur unless the pump operates. In summer the fire may be controlled to maintain a lower water temperature than when heating generally about 20 F warmer than that desired in the domestic hot water system.

In buildings which have restaurants it is generally desirable to install two separate service hot water systems so that water at about 180 F minimum may be available for dish washing, while water at 140 F maximum may be used for lavatory and bath purposes.

The temperature-controlling aquastat in a hot water storage tank should be no higher than the center of the tank, and possibly should be even closer to the bottom since water in a tank stratifies proportionally to the temperature. When hot water is removed, the cold water entering to replace it quickly reduces the temperature in the lower parts of the tank.

SOLAR WATER HEATERS

Solar heaters utilize the energy of the sun for heating hot water. The successful operation of such heaters require the availability of sunshine practically every day in the year, which has limited their use to Florida and the southern portions of California. When supplemented with some other means of gas, coal or oil water heating, solar heaters may be used in climates where sunshine may be more or less intermittent. They have been used in summer homes as far north as Chicago. When properly installed and proportioned solar water heaters render satisfactory service especially in climates where the outside temperatures are high and extremely hot water is not necessarily desirable. Such installations consist essentially of a storage tank, heating coil and hot box. The coil is installed in the hot box and is arranged to circulate water to and from the storage tank. The advantage in the use of this type of heater is the fact that it requires no fuel. The same materials should be used for the coil, circulation lines and tank. A copper coil is more efficient in absorbing heat in the box but galvanized iron or steel may be substituted depending on the local water conditions, cost and other considerations.

The storage tank must be able to store sufficient heated water for the night period of about 16 hr when the coil is not functioning or is operating under such poor sun conditions as to make its heating effect negligible. Due to the fact that the no sun period includes the night period when little or no hot water is used, an available storage of 50 per cent of the average daily usage is considered adequate. Since about 25 per cent of stored hot water cannot be drawn out of a storage tank before the in-

coming cold water reduces the temperature of all of the water in the tank to an unsatisfactory point for usage, the equation for calculating the storage capacity of the tank becomes:

$$S = \frac{Q \times 0.50}{0.75} = 0.666Q \quad (4)$$

where

S = storage capacity of tank, gallons.

Q = average daily usage, gallons.

Thus for a family of four persons using an average of 40 gal of hot water per person per day the size of the tank would be 4 persons x 40 gal x 0.666 or 106 gal, and the nearest standard size of tank to this theoretical

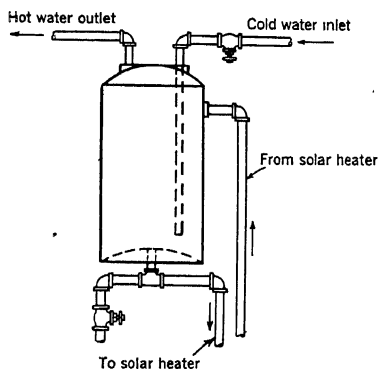


FIG. 10. SOLAR HEATER
TANK CONNECTIONS

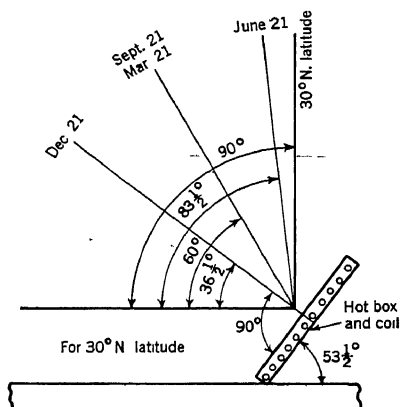


FIG. 11. SOLAR HEATING
COIL INCLINATION

capacity would be used. The tank should be well insulated to prevent undue loss of heat during the 16 hr period when the coil is inoperative and it should be located as high as possible in the building (under the peak of the roof if such exists) so as to secure a maximum circulation head from the coil. The hot water supply to the house, as shown in Fig. 10, is located at the top of the tank, which serves to air vent the tank by blowing air out through the hot water faucets in small bubbles as fast as it accumulates.

The coil should be of the return bend type, square or slightly rectangular in form, and should have the pipes running east and west, with the coil on the south side of the building where it can receive the full sun effect all day long without shadows from the building itself or from adjacent obstructions such as trees or other structures. The coil should be placed as low as possible in relation to the storage tank level, such as on a porch roof, the roof of a one-story extension or, if necessary, even on the ground. Both the coil and the circulation lines should be designed to facilitate the circulation flow as much as possible using long radius copper fittings or recessed galvanized iron fittings to match the materials of the

TABLE 12. SUGGESTED SOLAR HEATER DESIGN DATA^a

DESIGN ITEM	BASED ON RATE OF 30 GAL PER DAY PER PERSON								BASED ON RATE OF 40 GAL PER DAY PER PERSON							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
No. Occupants in Residence . . .																
Hot Water Used at Night, gal per person	15	15	15	15	15	15	15	15	20	20	20	20	20	20	20	20
Hot Water Used at Night, gal total .	15	30	45	60	75	90	105	120	20	40	60	80	100	120	140	160
Retained in Tank, 25 per cent, gal	4	8	11	15	19	23	27	30	5	10	15	20	25	30	35	40
Tank Capacity Required, gal	20	40	59	75	94	113	130	150	25	50	75	100	125	150	175	200
Hot Water Used During Day, gal . .	15	30	45	60	75	90	105	120	20	40	60	80	100	120	140	160
Total Water to be Heated:																
Gal per 8 hr period	35	70	104	135	169	203	235	270	45	90	135	180	225	270	315	360
Gal per hour	4.5	9	13	17	21	26	29	34	6	12	17	23	28	34	39	45
Copper Coil Required:																
Surface area, sq ft	25	50	75	100	121	145	168	192	32	64	96	128	160	192	224	256
Equivalent length 1 in. coil, ft.	100	200	300	400	484	580	664	768	128	256	384	512	640	768	896	1024
Box Size:																
Area, sq ft	25	50	75	100	121	145	168	192	32	64	96	128	160	192	224	256
Width, ft	4	6	7	8	9	10	10	11	4	6	8	9	10	11	12	13
Length, ft	6	8	11	12.5	13.5	14.5	16.5	17.5	8	10	12	14	16	18	19	21

^aSun Effect and the Design of Solar Heaters, by H. L. Alt (A.S.H.V.E. TRANSACTIONS, Vol. 41, 1935, p. 131).

coil, circulation lines and tank. The coil should be inclined as shown in Fig. 11 so that the north end is raised above the south end to secure an angle with the horizontal of about 53 deg. This will result in the inlet end of the coil being on the south side (or bottom) and the outlet end being on the north side (or top). This will satisfy conditions along the 30 deg N latitude which includes the portions of Florida and Southern California where these heaters are most frequently used.

The hot box is usually constructed of wood on the four sides and bottom and is insulated. Over the top of the box glass sash are placed and the box should be constructed as near air tight as possible. The interior surfaces should be painted white to reflect the heat while the coil should be painted black to absorb the heat. The box need not be deeper than necessary to house the coil and to protect it from the weather.

The addition of a light gage copper plate on the bottom of the box to which the pipe of the coil is soldered, for good metallic contact, will add to the amount of heat received by the coil due to the fact that this plate will receive all of the sun rays which fail to directly strike the coil. The heat from this source is transmitted to the coil through the plate instead of by heating the air surrounding the coil and from which only part of the heat enters the coil, the balance being transmitted through the glass sash.

Design data given in Table 12 may be used with some judgment in selecting the size of solar heater coil and box for a particular application. These data are based on consumptions of 30 and 40 gal of hot water per day per person.

Chapter 47

TERMINOLOGY

Glossary of Physical and Heating, Ventilating, Refrigerating and Air Conditioning Terms Used in the Text

Absolute Humidity: See *Humidity*.

Absolute Pressure: The pressure referred to that of a perfect vacuum. It is the sum of gage pressure and barometric pressure.

Absolute Temperature: A reading on the absolute temperature scale. Absolute temperature is obtained by adding 459.70 degrees to the Fahrenheit temperature.

Absolute Zero: The zero point on the absolute scale 459.70 F below the zero of the Fahrenheit scale.

Acceleration: The rate of change of velocity. In the fps system this is expressed in units of one foot per second. $a = V \div t$.

Acceleration Due to Gravity: The rate of gain in velocity of a freely falling body, the value of which varies with latitude and elevation. The international gravity standard has the value of 980.665 cm per second per second or 32.174 ft per second per second, which is the actual value of this acceleration at sea level and about 45 deg latitude.

Adiabatic: An adjective descriptive of a process in which no heat is added to or extracted from the system executing the process.

Air Cleaner: A device designed for the purpose of removing air-borne impurities such as dusts, fumes and smokes. (Air cleaners include air washers and air filters.)

Air Conditioning: The simultaneous control of all or at least the first three of those factors affecting both the physical and chemical conditions of the atmosphere within any structure. These factors include temperature, humidity, motion, distribution, dust, bacteria, odors and toxic gases, most of which affect in greater or lesser degree human health or comfort. (See *Comfort Air Conditioning*.)

Air Washer: An enclosure in which air is forced through a spray of water in order to cleanse, humidify, or dehumidify the air.

Anemometer: An instrument for measuring the velocity of moving air.

Atmospheric Pressure: The pressure indicated by a barometer. *Standard atmospheric pressure* is a pressure of 76 cm mercury (density 13.5951 grams per cubic centimeter, gravity 980.665 cm per second per second). It is equivalent to 14.6959 lb per square inch or 29.921 in. of mercury at 32 F.

Baffle: A plate or wall for deflecting gases or fluids.

Blast: This word was formerly used to denote forced air circulation, particularly in connection with central fan systems using steam or hot water as the heating medium. As applied in this sense, the word *blast* is now obsolete.

Boiler: A closed vessel in which steam is generated or in which water is heated.

Boiler Heating Surface: That portion of the surface of the heat-transfer apparatus in contact with the fluid being heated on one side and the gas or refractory being cooled on the other, in which the fluid being heated forms part of the circulating system; this surface shall be measured on the side receiving heat. This includes the boiler, water walls, water screens, and water floor. (*A.S.M.E. Power Test Codes, Series 1929*.)

Boiler Horsepower: The equivalent evaporation of 34.5 lb of water per hour from and at 212 F. This is equal to a heat output of $970.3 \times 34.5 = 33,475$ Btu per hour.

British Thermal Unit: A unit of energy defined in terms of the international steam-table calorie through the convenient relation 1 Btu per pound per degree Fahrenheit = 1 cal per gram per degree Centigrade. It is approximately the quantity of heat required to raise the temperature of 1 lb of liquid water from 63 to 64 F.

By-pass: A pipe or duct, usually controlled by valve or damper, for short-circuiting fluid flow.

Calorie: (large calorie or kilogram calorie) is equal to 1000 international steam-table calories = 1/860 international kilowatthour. For practical purposes it may be considered as 1/100 of the heat required to raise the temperature of 1 kilogram of water from 0 to 100 C.

Central Fan System: A mechanical indirect system of heating, ventilating, or air conditioning, in which the air is treated or handled by equipment located outside the rooms served, usually at a central location, and is conveyed to and from the rooms by means of a fan and a system of distributing ducts. (See Chapter 21.)

Chimney Effect: The tendency in a duct or other vertical air passage for air to rise when heated, owing to its decrease in density.

Coefficient of Transmission: The amount of heat (Btu) transmitted *from air to air* in one hour per square foot of the wall, floor, roof or ceiling for a difference in temperature of 1 F *between the air on the inside and that on the outside of the wall, floor, roof or ceiling.*

Comfort Air Conditioning: The process by which simultaneously the temperature, moisture content, movement and quality of the air in enclosed spaces intended for human occupancy may be maintained within required limits. (See *Air Conditioning*.)

Comfort Line: The effective temperature at which the largest percentage of adults feels comfortable.

Comfort Zone (Average): The range of effective temperatures over which the majority (50 per cent or more) of adults feel comfortable. **Comfort Zone (Extreme):** The range of effective temperatures over which one or more adults feel comfortable. (See Chapter 2.)

Concealed Radiator: A heating device located within, adjacent to, or exterior to the room being heated but so covered or enclosed or concealed that the heat transfer surface of the device, which may be either a radiator or a convector, does not *see* the room. Such a device transfers its heat to the room largely by convection air currents.

Conductance: The amount of heat (Btu) transmitted from surface to surface in one hour through one square foot of a material or construction, whatever its thickness, when the temperature difference is 1 F between the two surfaces.

Conduction: The transmission of heat through and by means of matter unaccompanied by any obvious motion of the matter.

Conductivity: The amount of heat (Btu) transmitted in one hour through one square foot of a homogeneous material *1 in. thick* for a difference in temperature of 1 F between the two surfaces of the material.

Conductor (Heat): A material capable of readily conducting heat. The opposite of an insulator or insulation.

Constant Relative Humidity Line: Any line on the psychrometric chart representing a series of conditions which may be evaluated by one percentage of relative humidity; there are also *constant* dry-bulb lines, wet-bulb lines, effective temperature lines, vapor pressure lines, and lines showing other physical properties of air mixed with water vapor.

Convection: The transmission of heat by the circulation of a liquid or a gas such as air. Convection may be *natural* or *forced*.

Convector: A heat transfer surface designed to transfer its heat to surrounding air largely or wholly by convection. Such a surface may or may not be enclosed or concealed. When concealed and enclosed the resulting device is sometimes referred to as a concealed radiator. (See also definition of *Radiator*.) (See also Chapter 13.)

Decibel: A unit commonly used for expressing sound or noise intensities referred to an arbitrary reference level. It is defined by the relation $db = 10 \log_{10} \frac{P_1}{P_0}$, where P_1 is the unknown intensity, and P_0 is the reference level which is commonly taken as 10^{-18} watts per square centimeter.

Degree-Day: A unit, based upon temperature difference and time, used in specifying the nominal heating load in winter. For any one day there exists as many degree-days as there are degrees Fahrenheit difference in temperature between the mean temperature for the day and 65 F.

Degree of Saturation or Per Cent Saturation: The ratio of actual humidity ratio W to the saturation humidity ratio W_s corresponding to the actual temperature and the observed pressure. $\mu = \frac{W}{W_s}$ (Approximately the same as but not identical with *relative humidity*. See Chapter 1).

Dehumidification: The condensation of water vapor from air by cooling below the dew-point.

Dehydration: The removal of water vapor from air by the use of adsorbing or absorbing materials.

Density: The weight of a unit volume, expressed in pounds per cubic foot. $d = W \div V$.

Dew-Point Temperature: The temperature corresponding to saturation (100 per cent relative humidity) for a given moisture content.

Direct-Indirect Heating Unit: A heating unit located in the room or space to be heated and partially enclosed, the enclosed portion being used to heat air which enters from outside the room.

Direct Radiator: Same as *Radiator*.

Direct-Return System (Hot Water): A hot water system in which the water, after it has passed through a heating unit, is returned to the boiler along a direct path so that the total distance traveled by the water is the shortest feasible, and so that there are considerable differences in the lengths of the several circuits composing the system.

Down-Feed One-Pipe Riser (Steam): A pipe which carries steam downward to the heating units and into which the condensation from the heating units drain.

Down-Feed System (Steam): A steam heating system in which the supply mains are above the level of the heating units which they serve.

Draft Head (Side Outlet Enclosure): The height of a gravity convector between the bottom of the heating unit and the bottom of the air outlet opening. (*Top Outlet Enclosure*): The height of a gravity convector between the bottom of the heating unit and the top of the enclosure.

Drip: A pipe, or a steam trap and a pipe, considered as a unit, which conducts condensation from the steam side of a piping system to the water or return side of the system.

Dry Air: In psychrometric work, *dry air* is defined as air without water vapor. This state, though not obtained practically, is used as the basis of calculations.

Dry-Bulb Temperature: The temperature indicated by a standardized thermometer after correction for radiation, etc.

Dry Return: A return pipe in a steam heating system which carries both water of condensation and air. The dry return is above the level of the water line in the boiler in a gravity system. (See *Wet Return*.)

Dust: Solid material in a finely divided state, the particles of which are large and heavy enough to fall with increasing velocity, due to gravity in still air. For instance, particles of fine sand or grit, the average diameter of which is approximately 0.01 centimeter, such as are blown on a windy day, may be called dust.

Dynamic Head or Pressure: Same as *Total Pressure*.

Effective Temperature: An arbitrary index which combines into a single value the effect of temperature, humidity, and movement of air on the degree of warmth or cold felt by the human body. The numerical value is that of the temperature of still, saturated air which would induce an identical sensation of warmth.

Enthalpy: A thermodynamic property which serves as a measure of the quantity of thermal energy *conveyed* by a fluid in steady flow. In a non-flow process the increase of enthalpy equals the quantity of heat absorbed *provided pressure is constant*. Enthalpy was formerly called *heat content*, sometimes *total heat*. Specific enthalpy is the ratio of total enthalpy to total weight, that is, enthalpy per unit weight of substance, Btu per pound.

Entropy: A thermodynamic property which, for practical purposes, is best defined by stating its principal functions: (1) during a reversible *adiabatic* change of state, entropy is constant; (2) during a reversible *isothermal* change of state, the heat absorbed is equal to absolute temperature times change of entropy. *Specific entropy* is the ratio of total entropy to total weight, that is, entropy per unit weight, Btu per degree Fahrenheit per pound.

Equivalent Evaporation: The amount of water a boiler would evaporate, in pounds per hour, if it received feed water at 212 F and vaporized it at the same temperature and atmospheric pressure.

Estimated Design Load: The sum of the heat emission of the equivalent direct radiation to be installed plus the allowance for heat loss of the connecting piping plus the heat requirements of any auxiliary apparatus connected with the system.

Estimated Maximum Load: The load stated in Btu per hour or equivalent direct radiation that has been estimated to be the greatest or maximum load that the boiler will be called upon to carry.

Extended Heating Surface: See *Heating Surface*.

Extended Surface Heating Unit: A heating unit having a relatively large amount of extended surface which may be integral with the core containing the heating medium or assembled over such a core, making good thermal contact by pressure or by being

soldered to the core or by both pressure and soldering. An extended surface heating unit is usually placed within an enclosure and therefore functions as a convector.

Fan Furnace System: See *Warm Air Heating System*.

Force: The action on a body which tends to change its relative condition as to rest or motion. $F = (WV) \div (gt)$.

Free Enthalpy: A thermodynamic property which serves as a measure of the available energy of a system with respect to surroundings at the same temperature and same pressure as that of the system. No process involving an increase in available energy can occur spontaneously. (See example on *Free Enthalpy* in Chapter 1.)

Fumes: Particles of solid matter resulting from such chemical processes as combustion, explosion, and distillation, ranging from 0.1 to 1.0 micron in size.

Furnace: That part of a boiler or warm air heating plant in which combustion takes place. Also, a fire-pot.

Furnace Volume (Total): The total furnace volume for horizontal-return tubular boilers and water-tube boilers is the cubical contents of the furnace between the grate and the first plane of entry into or between tubes. It therefore includes the volume behind the bridge wall as in ordinary horizontal-return tubular boiler settings, unless manifestly ineffective (*i.e.*, no gas flow taking place through it), as in the case of waste-heat boilers with auxiliary coal furnaces, where one part of the furnace is out of action when the other is being used. For Scotch or other internally fired boilers it is the cubical contents of the furnace, flues and combustion chamber, up to the plane of first entry into the tubes. (*A.S.M.E. Power Test Codes, Series 1929.*)

Gage Pressure: Pressure measured from atmospheric pressure as a base. Gage pressure may be indicated by a manometer which has one leg connected to the pressure source and the other exposed to atmospheric pressure.

Grate Area: The area of the grate surface, measured in square feet, to be used in estimating the rate of burning fuel. This area is construed to mean the area measured in the plane of the top surface of the grate, except that with special furnaces, such as those having magazine feed, or special shapes, the grate area shall be the mean area of the active part of the fuel bed taken perpendicular to the path of the gases through it. For furnaces having a secondary grate, such as those in double-grate down draft boilers, the effective area shall be taken as the area of the upper grate plus one-eighth of the area of the lower grate, both areas being estimated as previously defined.

Gravity Warm Air Heating System: See *Warm Air Heating System*.

Heat: Heat is that form of energy which transfers from one system to a second system at lower temperature by virtue of the temperature difference, when the two are brought into communication.

Heating Medium: A substance such as water, steam, air, or furnace gas used to convey heat from the boiler, furnace or other source of heat or energy to the heating unit from which the heat is dissipated.

Heating Surface: The exterior surface of a heating unit. *Extended heating surface (or extended surface):* Heating surface having air on both sides and heated by conduction from the prime surface. *Prime Surface:* Heating surface having the heating medium on one side and air (or extended surface) on the other. (See also *Boiler Heating Surface*.)

Heat of the Liquid: This can usually be interpreted as the specific enthalpy of saturated liquid.

Hot Water Heating System: A heating system in which water is used as the medium by which heat is carried through pipes from the boiler to the heating units.

Humid Heat: Ratio of increase of enthalpy per pound of dry air to rise of temperature under conditions of constant pressure and constant humidity ratio.

Humidify: To add water vapor to the atmosphere; to add water vapor or moisture to any material.

Humidistat: A regulatory device, actuated by changes in humidity, used for the automatic control of relative humidity.

Humidity: Water vapor when mixed with dry air or other diluent gases. *Absolute humidity* is the weight of water vapor per unit volume of moist air, pounds per cubic foot. It can be calculated by dividing the humidity ratio, weight of water vapor per pound of dry air, by the volume of the mixture per pound of dry air. *Relative humidity* is the ratio of the partial pressure of the water vapor in the air to the saturation pressure of pure water corresponding to the actual temperature. (See Chapter 1.)

Humidity Ratio: Weight of water vapor per pound of dry air. (Formerly called specific humidity.)

Hygrostat: Same as *Humidistat*.

Inch of Water: The pressure due to a column of liquid water one inch high at a temperature of 60 F.

Insulation (Heat): A material having a relatively high heat-resistance per unit of thickness.

Isobaric: An adjective used to indicate a change taking place at constant pressure.

Isothermal: An adjective used to indicate a change taking place at constant temperature.

Latent Heat: The most general interpretation is heat absorbed at constant temperature. More specifically the *latent heat of vaporization* is the difference between the specific enthalpies of saturated vapor and saturated liquid at the same temperature (and, for a pure substance, the same pressure). *Latent heat of sublimation* is the difference between the specific enthalpies of saturated vapor and saturated solid at the same temperature. *Latent heat of fusion* is the difference between the specific enthalpies of saturated liquid and saturated solid at the same temperature.

Laws of Thermodynamics: The Law of Conservation of Energy states that energy, in any of its forms, can neither be created nor destroyed. As a corollary to this, the *First Law* of Thermodynamics states that in any power cycle or refrigeration cycle the net heat absorbed by the working substance is exactly equal to the net work done. The *Second Law* of Thermodynamics states that a power cycle which absorbs heat at a single temperature and converts it wholly into work, as required by the First Law, is impossible; hence it is absolutely necessary to reject heat at some lower temperature if any work is to be done. The Second Law further prescribes the least possible quantity of heat that must be so rejected depending on the two temperatures involved.

Manometer: An instrument for measuring pressures; essentially a U-tube partially filled with a liquid, usually water, mercury, or a light oil, so the amount of displacement of the liquid indicates the pressure being exerted on the instrument.

Mass: The quantity of matter, in pounds, to which the unit of force (one pound) will give an acceleration of one foot per second per second. $m = W \div g$.

Mb, Mbh: Symbols which represent, respectively, 1000 Btu and 1000 Btu per hour.

Mechanical Equivalent of Heat: The conversion factor from Btu to foot pounds; $J = 778.26$ foot pounds per Btu. This is also referred to as Joule's Equivalent.

Micron: A unit of length, the thousandth part of one millimeter or the millionth of a meter.

Mol (Pound Mol): A weight in pounds numerically equal to the molecular weight of a substance. In the case of gases, and at not too high pressures, the volume of 1 mol is approximately the same for any gas at the same temperature and pressure. At 32 F and standard atmospheric pressure this volume is 358.65 cu ft.

One-Pipe Supply Riser (Steam): A pipe which carries steam upward to a heating unit and which also carries the condensation from the heating unit in a direction opposite to the steam flow.

One-Pipe System (Hot Water): A hot water system in which the water flows through more than one heating unit before it returns to the boiler; consequently, the heating units farthest from the boiler are supplied with cooler water than those near the boiler in the same circuit.

One-Pipe System (Steam): A steam heating system consisting of a main circuit in which the steam and condensate flow in the same pipe, usually in opposite directions. Ordinarily to each heating unit there is but one connection which must serve as both the supply and the return, although separate supply and return connections may be used.

Overhead System: Any steam or hot water system in which the supply main is above the heating units. With a steam system the return must be below the heating units; with a water system, the return may be above the heating units.

Panel Radiator: A heating unit placed on or flush with a flat wall surface and intended to function essentially as a radiator.

Panel Warming: A method of heating involving the installation of the heating units (pipe coils) within the wall, floor or ceiling of the room, so that the heating process takes place mainly by radiation from the wall, floor or ceiling surfaces to the objects in the room.

Plenum Chamber: An air compartment maintained under pressure and connected to one or more distributing ducts.

Potentiometer: An instrument for measuring or comparing small electromotive forces.

Power: The rate of performing work; usually expressed in units of horsepower, Btu per hour, or watts.

Prime Surface: See *Heating Surface*.

Psychrometer: An instrument for ascertaining the humidity or hygrometric state of the atmosphere. *Psychrometric:* Pertaining to psychrometry or the state of the atmosphere as to moisture. *Psychrometry:* The branch of physics that treats of the measurement of degree of moisture, especially the moisture mixed with the air.

Pyrometer: An instrument for measuring high temperatures.

Radiation: The transmission of heat through space by wave motion.

Radiator: A heating unit exposed to view within the room or space to be heated. A radiator transfers heat by radiation to objects *it can see* and by conduction to the surrounding air which in turn is circulated by natural convection; a so-called *radiator* is also a *convector* but the single term *radiator* has been established by long usage.

Recessed Radiator: A heating unit set back into a wall recess but not enclosed.

Refrigerant: A substance which produces a refrigerating effect by its absorption of heat while expanding or vaporizing.

Relative Humidity: See *Humidity*; also discussion relative humidity, Chapter 1.

Return Mains: The pipes which return the heating medium from the heating units to the source of heat supply.

Reversed-Return System (Hot Water): A hot water heating system in which the water from several heating units is returned along paths arranged so that all circuits composing the system or composing a major sub-division of the system are practically of equal length.

Roof Ventilator: A device placed on the roof of a building to facilitate egress of air.

Saturated Air: A mixture of dry air and saturated water vapor, all at the same dry-bulb temperature. It may also be considered as air containing the maximum possible amount of water vapor at a given temperature without becoming supersaturated.

Saturation: The condition for coexistence in stable equilibrium of two or more distinct phases, such as steam over the water from which it is being generated.

Saturation Pressure: The saturation pressure for a pure substance for any given temperature is that pressure at which vapor and liquid or vapor and solid can coexist in stable equilibrium.

Sensible Heat: Heat which manifests itself by temperature change.

Smoke: Carbon or soot particles less than 0.1 micron in size which result from the incomplete combustion of carbonaceous materials such as coal, oil, tar, and tobacco.

Smokeless Arch: An inverted baffle placed in an up-draft furnace toward the rear to aid in mixing the gases of combustion and thereby to reduce the smoke produced.

Specific Enthalpy: The ratio of total enthalpy to total weight. The specific enthalpy of air is its enthalpy, Btu per pound, measured above 0 F and 29.921 in. Hg as a reference point. The specific enthalpy of water is its enthalpy, Btu per pound, measured from the reference point of saturated liquid at 32 F. (See *Enthalpy*.)

Specific Gravity: The ratio of the weight of a body to the weight of an equal volume of water at some standard temperature, usually 39.2 F.

Specific Heat: The ratio of heat absorbed per unit weight of substance to temperature rise. For gases, both specific heat at constant pressure, c_p , and specific heat at constant volume, c_v , are frequently given. In air conditioning, c_p is usually used.

Specific Volume: The volume, expressed in cubic feet, of one pound of a substance.
 $v = 1 \div d = V \div W$.

Split System: A system in which the heating and ventilating are accomplished by means of radiators or convectors supplemented by mechanical circulation of air (heated or unheated) from a central point.

Square Foot of Heating Surface (Equivalent): Equivalent Direct Radiation (EDR). That amount of heating surface which will give off 240 Btu per hour. The *equivalent* square feet of heating surface may have no direct relation to the actual surface area.

Stack Height: The height of a gravity convector between the bottom of the heating unit and the top of the outlet opening.

Standard Air: Air weighing 0.075 lb per cubic foot. (The density of air at 29.921 in. of mercury barometric pressure, 68 F dry-bulb and 50 per cent relative humidity is 0.07497; and dry air at 70 F dry-bulb is 0.07496.)

Static Pressure: The normal force per unit area that would be exerted by a moving fluid on a small body immersed in it if the body were carried along with the fluid. Practi-

cally, it is the normal force per unit area at a small hole in a wall of the duct through which the fluid flows (piezometer) or on the surface of a stationary tube at a point where the disturbances created by inserting the tube cancel. It is supposed that the thermodynamic properties of a moving fluid depend on static pressure in exactly the same manner as those of the same fluid at rest depend upon its uniform hydrostatic pressure.

Steam: Water in the vapor phase. *Dry Saturated Steam* is steam at the saturation temperature corresponding to the pressure, and containing no water in suspension. *Wet Saturated Steam* is steam at the saturation temperature corresponding to the pressure, and containing water particles in suspension. *Superheated Steam* is steam at a temperature higher than the saturation temperature corresponding to the pressure.

Steam Heating System: A heating system in which heat is transferred from the boiler or other source of steam to the heating units by means of steam at, above, or below atmospheric pressure.

Steam Trap: A device for allowing the passage of condensate and preventing the passage of steam, or for allowing the passage of air as well as condensate.

Superheated Steam: See *Steam*.

Supply Mains (Steam): The pipes through which the steam flows from the boiler or source of supply to the run-outs and risers leading to the heating units.

Surface Conductance: The amount of heat (Btu) transmitted by radiation, conduction, and convection from a surface to the air or liquid surrounding it, or vice versa, in one hour per square foot of surface for a difference in temperature of 1 deg between the surface and the surrounding air or liquid.

Therm: 100,000 Btu. (Used in the gas industry.)

Thermal Resistance: The reciprocal of *conductance*.

Thermal Resistivity: The reciprocal of *conductivity*.

Thermostat: An instrument which responds to changes in temperature and which directly or indirectly controls the source of heat supply.

Ton of Refrigeration: The removal of 12,000 Btu of heat per hour at a low temperature.

Ton Day of Refrigeration: The removal of 288,000 Btu of heat at a low temperature.

Total Heat: This can usually be interpreted as increase of enthalpy at constant pressure. It is often regarded as synonymous with enthalpy.

Total Pressure: In the theory of the flow of fluids; the sum of the static pressure and the velocity pressure at the point of measurement.

Tube (or Tubular) Radiator: A cast-iron heating unit used as a radiator and having small vertical tubes.

Two-Pipe System (Steam or Water): A heating system in which one pipe is used for the supply of the heating medium to the heating unit and another for the return of the heating medium to the source of heat supply. The essential feature of a two-pipe system is that each heating unit receives a direct supply of the heating medium which medium cannot have served a preceding heating unit.

Underfeed Distribution System (Hot Water): A hot water heating system in which the main flow pipe is below the heating unit.

Underfeed Stoker: A stoker which feeds the coal underneath the fuel bed.

Unit: As applied to heating, ventilating and air conditioning equipment this word means a factory-built and assembled equipment with apparatus for accomplishing some specified function or combination of functions. (See Chapters 22 and 23.)

It is loosely applied to a great variety of equipment. Usually the function is included in the name, and hence come terms like Unit Heater, Unit Ventilator, Humidifying Unit, and Air Conditioning Unit.

Units are said to be *direct* or *room*, when intended for location, or located in, the treated space; *indirect* or *remote*, when outside or adjacent to the treated space. They are *ceiling* units when suspended from above, and *floor* when supported from below. Other descriptive words include *free delivery* when the unit is not intended to be attached to ducts or similar resistance-producing devices, and *pressure* when for use with such ducts. Complete description requires the use of several of these qualifying words or phrases. (See Chapter 23.)

Up-Feed System (Steam): A steam heating system in which the supply mains are below the level of the heating units which they serve.

Vacuum Heating System: A two-pipe steam heating system equipped with the necessary accessory apparatus which will permit operating the system below atmospheric pressure when desired.

Vapor: Any substance in the gaseous state.

Vapor Heating System: A steam heating system which operates under pressures at or near atmospheric and which returns the condensation to the boiler or receiver by gravity. Vapor systems have thermostatic traps or other means of resistance on the return ends of the heating units for preventing steam from entering the return mains; they also have a pressure-equalizing and air-eliminating device at the end of the dry return. *Direct Vent Vapor System:* A vapor heating system with air valves which do not permit re-entry of air.

Vapor Pressure: Synonymous with saturation pressure in the case of a pure substance.

Velocity: The time rate of motion of a body in a fixed direction. In the fps system it is expressed in units of one foot per second. $V = \frac{s}{t}$.

Velocity Pressure: The difference due to velocity between total pressure and static pressure. It is supposed to equal the kinetic energy per unit volume of the fluid at the point of measurement.

Ventilation: The process of supplying or removing air by natural or mechanical means, to or from any space. Such air may or may not have been conditioned. (See *Air Conditioning*.)

Warm Air Heating System: A warm air heating plant consists of a heating unit (fuel-burning furnace) enclosed in a casing, from which the heated air is distributed to the various rooms of the building through ducts. If the motive head producing flow depends on the difference in weight between the heated air leaving the casing and the cooler air entering the bottom of the casing, it is termed a *gravity* system. A booster fan may, however, be used in conjunction with a gravity-designed system. If a fan is used to produce circulation and the system is designed especially for fan circulation, it is termed a *fan furnace* system or a *central fan furnace* system. A fan furnace system may include air washers and filters.

Wet-Bulb Temperature: *Thermodynamic wet-bulb temperature* is the temperature at which liquid or solid water, by evaporating into air, can bring the air to saturation adiabatically at the same temperature. *Wet-bulb temperature* (without qualification) is the temperature indicated by a wet-bulb psychrometer constructed and used according to specifications. (A.S.M.E. Power Test Codes, Series 1932, Instruments and Apparatus, Part 18.)

Wet Return: That part of a return main of a steam heating system which is filled with water of condensation. The wet return usually is below the level of the water line in the boiler, although not necessarily so. (See *Dry Return*.)

Chapter 48

ABBREVIATIONS, SYMBOLS, STANDARDS

Standard Abbreviations, Conversion Equations, Graphical Symbols for Piping, Ductwork, Heating and Ventilating, Refrigerating, Specific Heat Table, State Codes or Standards

THE abbreviations outlined herewith pertaining to heating, ventilating, and air conditioning have been compiled from a selected list of approved standards¹. In general the period has been omitted in all these abbreviations except where the omission results in the formation of an English word. Grouped together in this chapter will be found a few conveniently arranged conversion equations. The graphical symbols for drawings have been abstracted from a recently approved standard².

The specific heats of a selected list of solids, liquids, gases and vapors are given in Tables 1, 2 and 3.

An outline of available state codes, standards or laws relating to the heating, ventilating, or air conditioning of various types of buildings is given in Table 4. This material was compiled by the A.S.H.V.E. and is based on information furnished by the individual states through a comprehensive survey conducted in 1942. References are given to the titles of all codes, standards or laws which relate to this field of engineering and where copies of these standards may be obtained.

Absolute.....	abs
Acceleration, due to gravity.....	g
Acceleration, linear.....	a
Air horsepower.....	air hp
Alternating-current (as adjective).....	a-c
Ampere.....	amp
Ampere-hour.....	amp-hr
Area.....	A
Atmosphere.....	atm
Average.....	avg
Avoirdupois.....	avdp
Barometer.....	bar.
Boiler pressure.....	bp
Boiling point.....	bp
Brake horsepower.....	bhp
Brake horsepower-hour.....	bhp-hr
British thermal unit.....	Btu
Calorie.....	cal
Centigram.....	cg
Centimeter.....	cm

¹Abbreviations for Scientific and Engineering Terms, Z10 1-1941; Letter Symbols for Mechanics of Solid Bodies, Z10 3-1942, and Symbols for Heat and Thermodynamics, Z10c-1931 (*American Standards Association*).

²Graphical Symbols for Use on Drawings in Mechanical Engineering, Z32.2-1941 (*American Standards Association*).

Centimeter-gram-second (system).....	cgs
Change in specific volume during vaporization.....	Δv_g
Cubic.....	cu
Cubic foot.....	cu ft
Cubic feet per minute.....	cfm
Cubic feet per second.....	cfs
Decibel.....	db
Degree ³	deg or °
Degree centigrade.....	C
Degree Fahrenheit.....	F
Degree Kelvin.....	K
Degree Réaumur.....	R
Density, Weight per unit volume, Specific weight.....	d or ρ (rho)

$$d = \frac{1}{v}$$

Diameter.....	D or diam
Direct-current (as adjective).....	d-c
Distance, linear.....	s
Dry saturated vapor, Dry saturated gas at saturation pressure and temperature, vapor in contact with liquid.....	Subscript g
Entropy. (The capital should be used for any weight, and the small letter for unit weight).....	S or s
Feet per minute.....	fpm
Feet per second.....	fps
Foot.....	ft
Foot-pound.....	ft-lb
Foot-pound-second (system).....	fps
Force, total load.....	F
Freezing point.....	fp
Gallon.....	gal
Gallons per minute.....	gpm
Gallons per second.....	gps
Gram.....	g
Gram-calorie.....	g-cal
Head.....	H or h
Heat content, Total heat, Enthalpy. (The capital should be used for any weight and the small letter for unit weight).....	H or h
Heat content of saturated liquid, Total heat of saturated liquid, Enthalpy of saturated liquid, sometimes called heat of the liquid.....	h_f
Heat content of dry saturated vapor, Total heat of dry saturated vapor, Enthalpy of dry saturated vapor.....	h_g
Heat of vaporization at constant pressure.....	L or h_{fg}
Horsepower.....	hp
Horsepower-hour.....	hp-hr
Hour.....	hr
Inch.....	in.
Inch-pound.....	in.-lb
Indicated horsepower.....	ihp
Indicated horsepower-hour.....	ihp-hr
Internal energy, Intrinsic energy. (The capital should be used for any weight and the small letter for unit weight).....	U or u
Kilogram.....	kg
Kilowatt.....	kw
Kilowatthour.....	kwhr
Length of path of heat flow, thickness.....	L
Load, total.....	W
Mass.....	mass
Mechanical efficiency.....	e_m
Mechanical equivalent of heat.....	J
Melting point.....	mp
Meter.....	m

³It is recommended that the abbreviation for the temperature scale, F, C, K, be included in expressions for numerical temperatures but, wherever feasible, the abbreviations for *degree* be omitted; as 68 F.

CHAPTER 48. ABBREVIATIONS, SYMBOLS, STANDARDS

Micron.....	μ (mu)
Miles per hour.....	mph
Millimeter.....	mm
Minute.....	min
Molecular weight.....	mol. wt
Mol.....	mol
Ounce.....	oz
Pound.....	lb
Power, Horsepower, Work per unit time.....	P
Pressure, Absolute pressure, Gage pressure, Force per unit area.....	p
Quantity (total) of fluid, water, gas, heat; Quantity by volume; Total quantity of heat transferred.....	Q
Quality of steam, Pounds of dry steam per pound of mixture.....	x
Revolutions per minute.....	rpm
Saturated liquid at saturation pressure and temperature, Liquid in contact with vapor.....	Subscript f
Second.....	sec
Specific gravity.....	sp gr
Specific heat.....	sp ht or c
Specific heat at constant pressure.....	c _p
Specific heat at constant volume.....	c _v
Specific volume, Volume per unit weight, Volume per unit mass.....	v
Square foot.....	sq ft
Square inch.....	sq in.
Temperature (ordinary) F or C. (<i>Theta</i> is used preferably only when <i>t</i> is used for Time in the same discussion).....	<i>t</i> or <i>θ</i> (<i>theta</i>)
Temperature (absolute) F abs or K. (Capital <i>theta</i> is used preferably only when small <i>theta</i> is used for ordinary temperature).....	<i>T</i> or <i>Θ</i> (<i>capital theta</i>)
Thermal conductance ⁴ (heat transferred per unit time per degree).....	C

$$C = \frac{1}{R} = \frac{kA}{L} = \frac{q}{t_1 - t_2}$$

Thermal conductance per unit area, Unit conductance (heat transferred per unit time per unit area per degree).....C_a

$$C_a = \frac{C}{A} = \frac{1}{RA} = \frac{q}{A(t_1 - t_2)} = \frac{k}{L}$$

Thermal conductivity (heat transferred per unit time per unit area, and per degree per unit length).....k

$$k = \frac{\frac{q}{A}}{\frac{(t_1 - t_2)}{L}}$$

Surface coefficient of heat transfer, Film coefficient of heat transfer, Individual coefficient of heat transfer (heat transferred per unit time per unit area per degree).....f

$$f = \frac{\frac{q}{A}}{t_1 - t_2}$$

(In general *f* is not equal to *k/L*, where *L* is the actual thickness of the fluid film.)

Over-all coefficient of heat transfer, Thermal transmittance per unit area (heat transferred per unit time per unit area per degree over-all).....U

$$U = \frac{\frac{q}{A}}{t_1 - t_2}$$

⁴Terms ending *ity* designate properties independent of size or shape, sometimes called *specific properties*. Examples: conductivity, resistivity. Terms ending *ance* designate quantities depending not only on the material, but also upon size and shape, sometimes called *total quantities*. Examples: conductance, transmittance. Terms ending *ion* designate rate of heat transfer. Examples: conduction, transmission

Thermal transmission (heat transferred per unit time).....	q
	$q = \frac{Q}{t}$
Thermal resistance (degrees per unit of heat transferred per unit time)	R
	$R = \frac{t_1 - t_2}{q} = \frac{L}{kA}$
Thermal resistivity.....	$1/k$
Vaporization values at constant pressure, Differences between values for saturated vapor and saturated liquid at the same pressure.....	<i>Subscript fg</i>
Velocity.....	V
Volume (total).....	V
Volume per unit time, Rate at which quantity of material passes through a machine, Quantity of heat per unit time, Quantity of heat per unit weight.....	q
Watt.....	w
Watthour.....	whr
Weight of a major item, Total weight.....	W
Weight rate, Weight per unit of power, Weight per unit of time.....	w
Work (total).....	W

CONVERSION EQUATIONS

Heat, Power and Work

1 ton refrigeration	= { 12,000 Btu per hour 200 Btu per minute
Latent heat of ice	= 143.4 Btu per pound
1 Btu	= { 778.26 ft-lb 0.293 whr 252 mean calories 2,655 ft-lb 3.413 Btu 3600 joules 860 mean calories
1 watthour	= { 3,413 Btu 3.517 lb water evaporated from and at 212 F
1 kilowatthour	= { 1.341 hp 56.88 Btu per minute 44,253 ft-lb per minute
1000 mean calorie } 1 kilogram calorie }	= { 3.969 Btu 3087 ft-lb 1.1627 whr
1 horsepower	= { 0.746 kw 42.42 Btu per minute 33,000 ft-lb per minute 550 ft-lb per second
1 boiler horsepower	= { 33,475 Btu per hour 9.808 kw

Weight and Volume

1 gal (U. S.)	= { 231 cu in. 0.1337 cu ft
1 British or Imperial gallon	= 277.42 cu in.
1 cu ft	= { 7.48 gal 1728 cu in.
1 cu ft water at 60 F	= 62.37 lb
1 cu ft water at 212 F	= 59.83 lb
1 gal water at 60 F	= 8.34 lb
1 gal water at 212 F	= 7.998 lb
1 lb (avdp)	= { 16 oz 7000 grains
1 bushel	= 1.244 cu ft
1 short ton	= 2000 lb

Pressure

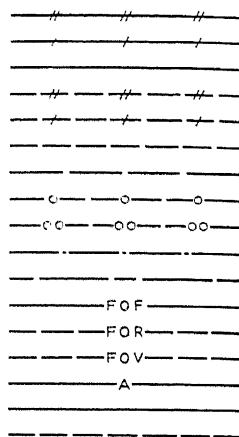
1 lb per square inch	=	$\left\{ \begin{array}{l} 144 \text{ lb per square foot} \\ 2.0421 \text{ in. mercury at } 62^\circ \text{ F} \\ 2.309 \text{ ft water at } 62^\circ \text{ F} \\ 27.71 \text{ in. water at } 62^\circ \text{ F} \end{array} \right.$
1 oz per square inch	=	$\left\{ \begin{array}{l} 0.1276 \text{ in. mercury at } 62^\circ \text{ F} \\ 1.732 \text{ in. water at } 62^\circ \text{ F} \end{array} \right.$
1 atmosphere	=	$\left\{ \begin{array}{l} 14.6959 \text{ lb per square inch} \\ 2117 \text{ lb per square foot} \\ 33.9 \text{ ft water at } 62^\circ \text{ F} \\ 30 \text{ in. mercury at } 62^\circ \text{ F} \\ 29.921 \text{ in. mercury at } 32^\circ \text{ F} \end{array} \right.$
1 in. water at 62 F	=	$\left\{ \begin{array}{l} 0.03609 \text{ lb per square inch} \\ 0.5774 \text{ oz per square inch} \\ 5.196 \text{ lb per square foot} \end{array} \right.$
1 ft water at 62 F	=	$\left\{ \begin{array}{l} 0.433 \text{ lb per square inch} \\ 62.35 \text{ lb per square foot} \end{array} \right.$
1 in. mercury at 62 F	=	$\left\{ \begin{array}{l} 0.491 \text{ lb per square inch} \\ 7.84 \text{ oz per square inch} \\ 1.131 \text{ ft water at } 62^\circ \text{ F} \\ 13.58\text{-in. water at } 62^\circ \text{ F} \end{array} \right.$

Metric Units

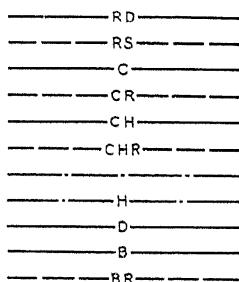
1 cm	=	0.3937 in.
1 in.	=	2.540 cm
1 m	=	3.281 ft
1 ft	=	0.3048 m
1 sq cm	=	0.155 sq in.
1 sq in.	=	6.452 sq cm
1 sq m	=	10.76 sq ft
1 sq ft	=	0.0929 sq m
1 cu cm	=	0.06102 cu in.
1 cu in.	=	16.39 cu cm
1 cu m	=	35.31 cu ft
1 cu ft	=	0.02831 cu m
1 liter	=	1000 cu cm = 0.2642 gal
1 kg	=	2.205 lb (avdp)
1 lb	=	0.4536 kg
1 metric ton	=	2205 lb (avdp)
1 gram	=	0.002205 lb (avdp)
1 kilometer per hour	=	0.6214 mph
1 gram per square centimeter	=	$\left\{ \begin{array}{l} 0.02905 \text{ in. mercury at } 62^\circ \text{ F} \\ 0.3944 \text{ in. water at } 62^\circ \text{ F} \end{array} \right.$
1 kg per sq cm (metric atmosphere)	=	14.22 lb per square inch
1 gram per cubic centimeter	=	$\left\{ \begin{array}{l} 0.03613 \text{ lb per cubic inch} \\ 62.43 \text{ lb per cubic foot} \end{array} \right.$
1 dyne	=	0.00007233 poundals
1 joule	=	$\left\{ \begin{array}{l} 10,000,000 \text{ ergs} \\ 0.7376 \text{ ft-lb} \end{array} \right.$
1 metric horsepower	=	$\left\{ \begin{array}{l} 75 \text{ kg-m per second} \\ 0.986 \text{ hp (U. S.)} \end{array} \right.$
1 kilogram-calorie per kilogram	=	1.8 Btu per pound
1 gram-calorie per square centimeter	=	3.687 Btu per square foot
1 gram-calorie per square centimeter per centimeter	=	1.452 Btu per sq ft per inch
1 gram-calorie per second per square centimeter for a temperature gradient of 1 deg C per centimeter.	=	$\left\{ \begin{array}{l} 2903 \text{ Btu per hour per square foot for a temperature gradient of } 1^\circ \text{ deg F per inch of thickness.} \end{array} \right.$

GRAPHICAL SYMBOLS FOR DRAWINGS
Piping
HEATING

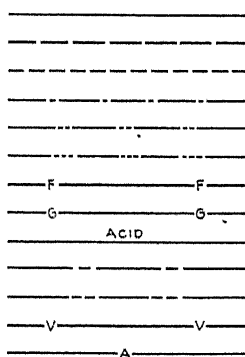
1. High Pressure Steam
2. Medium Pressure Steam
3. Low Pressure Steam
4. High Pressure Return
5. Medium Pressure Return
6. Low Pressure Return
7. Boiler Blow Off
8. Condensate or Vacuum Pump Discharge
9. Feedwater Pump Discharge
10. Make Up Water
11. Air Relief Line
12. Fuel Oil Flow
13. Fuel Oil Return
14. Fuel Oil Tank Vent
15. Compressed Air
16. Hot Water Heating Supply
17. Hot Water Heating Return


AIR CONDITIONING

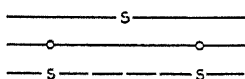
18. Refrigerant Discharge
19. Refrigerant Suction
20. Condenser Water Flow
21. Condenser Water Return
22. Circulating Chilled or Hot Water Flow
23. Circulating Chilled or Hot Water Return
24. Make Up Water
25. Humidification Line
26. Drain
27. Brine Supply
28. Brine Return


PLUMBING

29. Soil, Waste or Leader (Above Grade)
30. Soil, Waste or Leader (Below Grade)
31. Vent
32. Cold Water
33. Hot Water
34. Hot Water Return
35. Fire Line
36. Gas
37. Acid Waste
38. Drinking Water Flow
39. Drinking Water Return
40. Vacuum Cleaning
41. Compressed Air


SPRINKLERS

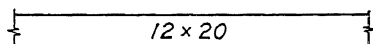
42. Main Supplies
43. Branch and Head
44. Drain



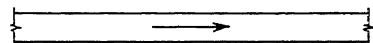
GRAPHICAL SYMBOLS FOR DRAWINGS

Ductwork

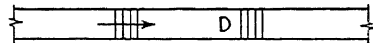
45. Duct (1st Figure, Width; 2nd, Depth)



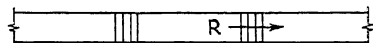
46. Direction of Flow



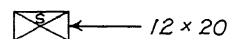
47. Inclined Drop in Respect to Air Flow



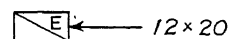
48. Inclined Rise in Respect to Air Flow



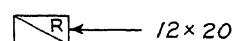
49. Supply Duct Section



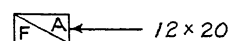
50. Exhaust Duct Section



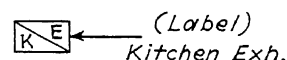
51. Recirculation Duct Section



52. Fresh Air Duct Section



53. Other Duct Sections



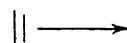
54. Register

R

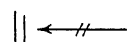
55. Grille

G

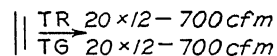
56. Supply Outlet



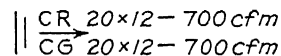
57. Exhaust Inlet



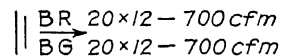
58. Top Register or Grille



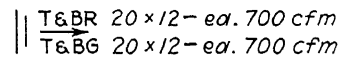
59. Center Register or Grille



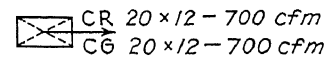
60. Bottom Register or Grille



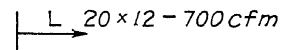
61. Top and Bottom Register or Grille



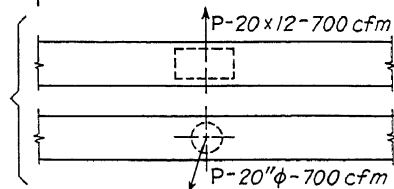
62. Ceiling Register or Grille



63. Louver Opening



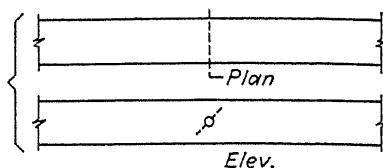
64. Adjustable Plaque



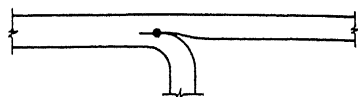
GRAPHICAL SYMBOLS FOR DRAWINGS

Ductwork

65. Volume Damper



66. Deflecting Damper



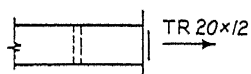
67. Deflecting Damper, Up



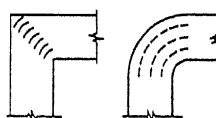
68. Deflecting Damper, Down



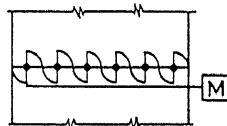
69. Adjustable Blank Off



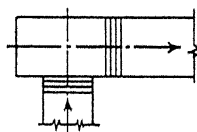
70. Turning Vanes



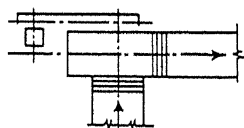
71. Automatic Dampers



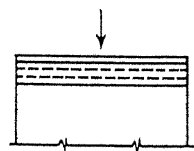
72. Canvas Connections



73. Fan and Motor With Guard



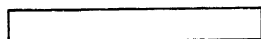
74. Intake Louvers and Screen



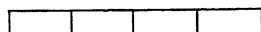
GRAPHICAL SYMBOLS FOR DRAWINGS

Heating and Ventilating

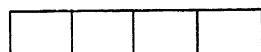
75. Heat Transfer Surface, Plan



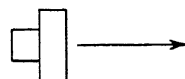
76. Wall Radiator, Plan



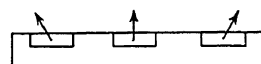
77. Wall Radiator on Ceiling, Plan



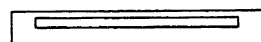
78. Unit Heater (Propeller), Plan



79. Unit Heater (Centrifugal Fan), Plan

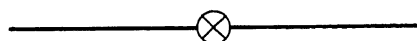


80. Unit Ventilator, Plan

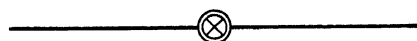


TRAPS

81. Thermostatic



82. Blast Thermostatic



83. Float and Thermostatic



84. Float

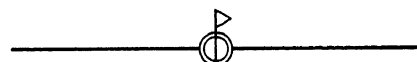


85. Boiler Return

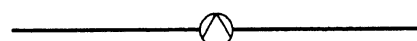


VALVES

86. Reducing Pressure



87. Air Line



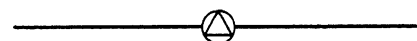
88. Lock and Shield



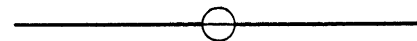
89. Diaphragm



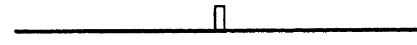
90. Air Eliminator



91. Strainer



92. Thermometer




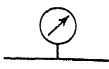
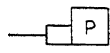
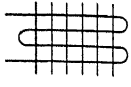

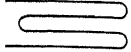

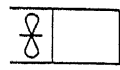


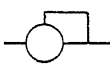

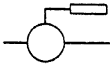
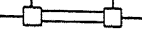
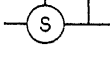
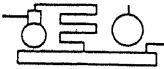
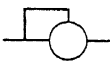
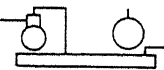


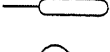










93. Thermostat



GRAPHICAL SYMBOLS FOR DRAWINGS

Refrigerating

94. Thermostat (Self Contained)		110. Low Side Float	
95. Thermostat (Remote Bulb)		111. Gage	
96. Pressurestat		112. Finned Type Cooling Unit, Natural Convection	
97. Hand Expansion Valve		113. Pipe Coil	
98. Automatic Expansion Valve		114. Forced Convection Cooling Unit	
99. Thermostatic Expansion Valve		115. Immersion Cooling Unit	
100. Evaporator Press. Regulating Valve, Throttling Type		116. Ice Making Unit	
101. Evaporator Press. Regulating Valve, Thermostatic Throttling Type		117. Heat Interchanger	
102. Evaporator Press. Regulating Valve, Snap-Action Valve		118. Condensing Unit, Air Cooled	
103. Compressor Suction Pressure Limiting Valve, Throttling Type		119. Condensing Unit, Water Cooled	
104. Hand Shut Off Valve		120. Compressor	
105. Thermal Bulb		121. Cooling Tower	
106. Scale Trap		122. Evaporative Condenser	
107. Dryer		123. Solenoid Valve	
108. Strainer		124. Pressurestat With High Pressure Cut-Out	
109. High Side Float			

CHAPTER 48. ABBREVIATIONS, SYMBOLS, STANDARDS

TABLE 1. SPECIFIC HEAT OF SOLIDS

MATERIALS	TEMPERATURE F	SPECIFIC HEAT	AUTHORITY
Alloys			
Brass, Red.....	32	0.0899	S
Brass, Yellow.....	32	0.0883	S
Bronze (80Cu, 20Sn).....	57-208	0.0862	S
Monel Metal.....	68-2370	0.127	S
Aluminum.....	80-212	0.212	S
Asbestos.....	68-208	0.195	S
Brickwork.....	.....	0.195	H
Carbon (Graphite).....	104-1637	0.314	I
Coal.....	.....	0.278	H
Coke.....	.....	0.201	H
Concrete.....	.....	0.270	H
Copper.....	64-212	0.0928	S
Fire Clay Brick.....	77-1832	0.258	I
Glass			
Crown.....	50-122	0.161	S
Flint.....	50-122	0.117	S
Gold.....	64	0.0312	S
Gypsum.....	.....	0.259	H
Ice.....	32	0.487	S
Ice.....	- 40	0.434	S
Iron, Pure.....	32	0.1043	S
Iron, Pure.....	32-600	0.127	M
Iron, Cast.....	68-212	0.1189	H
Iron, Wrought.....	59-212	0.1152	H
Lead.....	32	0.0297	S
Nickel.....	32	0.1032	S
Masonry.....	.....	0.2159	H
Plaster.....	.....	0.2	H
Platinum.....	58-212	0.0319	S
Rocks			
Gneiss.....	63-210	0.196	S
Granite.....	54-212	0.192	S
Limestone.....	59-212	0.216	S
Marble.....	32-212	0.21	S
Sandstone.....	.....	0.22	S
Silver.....	32	0.0536	S
Steel.....	.....	0.1175	H
Sulphur.....	240-320	0.220	S
Silica Brick.....	77-1832	0.263	I
Tin.....	77	0.0548	S
Woods (Average).....	68	0.327	S
Zinc.....	32	0.0913	S

TABLE 2. SPECIFIC HEAT OF LIQUIDS

LIQUID	TEMPERATURE F	SPECIFIC HEAT	AUTHORITY
Alcohol, Ethyl.....	32	0.548	S
Alcohol, Methyl.....	59-68	0.601	S
Glycerine.....	59-122	0.576	S
Lead (Molten).....	360	0.041	S
Mercury.....	68	0.03325	S
Petroleum.....	70-136	0.511	S
Sea Water			
Sp. Gr. 1.0043.....	64	0.980	S
Sp. Gr. 1.0463.....	64	0.903	S
Water.....	59	1.000	S

TABLE 3. SPECIFIC HEAT OF GASES AND VAPORS

SUBSTANCE	TEMPERATURE F	SPECIFIC HEAT AT CONSTANT PRESSURE	RATIO OF SPECIFIC HEAT C_p/C_v	SPECIFIC HEAT AT CONSTANT VOLUME (COMPUTED)	AUTHORITY
Air.....	32-392	0.2375	1.405	0.169	S
Ammonia.....	80-392	0.5356	1.277	0.419	S
Carbon Dioxide.....	52-417	0.2169	1.3003	0.1668	S
Carbon Monoxide.....	79-388	0.2426	1.395	0.1736	S
Coal Gas.....	68-1900	0.3145	.....	.....	S
Flue Gas.....	.....	0.24 (Approx.)	.....	.....	H
Hydrogen.....	70-212	3.41	1.419	2.402	S
Nitrogen.....	32-392	0.2438	1.41	0.1729	S
Oxygen.....	55-404	0.2175	1.3977	0.155	S
Water Vapor.....	212	0.421	1.305	0.322	S
Water Vapor.....	356	0.51	.....	.....	S

NOTES: When one temperature is given the true specific heat is given, otherwise the value is the mean specific heat between the given limits.

AUTHORITIES: S—Smithsonian Physical Tables, 1933; I—International Critical Tables; H—Heating, Ventilation and Air Conditioning, by L. A. Harding and A. C. Willard; M—Engineers' Handbook, by Lionel S. Marks

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TABLE 4. STATE CODES, STANDARDS OR LAWS RELATING TO THE HEATING, VENTILATING OR AIR CONDITIONING OF BUILDINGS

STATE	CODES, STANDARDS OR LAWS	WHERE MATERIAL CAN BE OBTAINED
ALABAMA	None.	
ARIZONA	Law 56-117. Laundry—hours of labor—ventilation—penalty; Law 65-218. Ventilation (with reference to mines).	Secretary of State, State House, Phoenix.
ARKANSAS	Installation of power boilers of 15 lb steam pressure or over.	Dept. of Labor, State Capitol, Little Rock.
CALIFORNIA	Reference to the ventilation laws may be found in the California Health and Safety Code under the following sections: Sec. 16800—Construction Requirements, Air Ducts. Sec. 16820-16835—Vent Shafts. Sec. 16900-16905—Gas Appliance Vents. Sec. 17080-17088—Garages. Sec. 16233-16235, 16270-16271—Rooms. Sec. 16300-16305—Stairways.	Supervisor of Documents, 214 State Capitol, Sacramento.
COLORADO	None.	
CONNECTICUT	School Building Code (1941); Chapter 6—Structural and Mechanical, D. Heating and Ventilation. Sanitary Code: Section 2566 specifies the number of cubic feet of air for children and adults in tenement and boarding houses; Regulation 280 and 281 is concerned with ventilation to be provided for industrial processes. Labor Laws (1939): VII. Industrial Safety, A. General, Sec. 2355—Lighting and sanitary condition of factories and round houses; VIII. Industrial Health and Sanitation, Legislation, Sec. 2355—Lighting and sanitary condition of factories and round houses.	State Dept. of Education, Div. of Instruction, Hartford. State Dept. of Health, Hartford. Dept. of Labor and Factory Inspection, Hartford.
DELAWARE	Minimum Standards for School Buildings and Sites (1931).	State Board of Education, Dover.
DISTRICT OF COLUMBIA	Building Code (1941), Section 505—Mechanical Ventilation; Section 702, Article 702-04—Construction of Air Conditioning Ducts.	Engineering Dept., Dept. of Inspection, Govt. District of Columbia.
FLORIDA	School Code Law; Laws Relating to Construction Hotels, Apartment Houses, and Public Eating Places.	Secy. of State, Tallahassee.
GEORGIA	None.	
IDAHO	None.	
ILLINOIS	Laws Relating to Labor and Employment (1941) Health and Safety Act; Occupational Diseases; Compressed Air Employment. Illinois School Law, Section 15, paragraph 20 is amplified in April, 1940, Educational Press Bulletin with sections on Ventilating and Heating.	Dept. of Labor, Capitol Bldg., Springfield. Superintendent of Public Instruction, Springfield.
INDIANA	Rules and Regulations of the State Board of Health Governing the Construction, Equipment and Maintenance of Sanitary Features of Public and Parochial School Buildings (1936). Rules and Regulations of the Administrative Building Council—Article VIII, Sections 19-8-1, 19-8-2 and 19-8-3 Pertaining to Ventilation of Rooms and Plumbing Fixtures.	Bureau Sanitary Engineering, State Board of Health, 1098 W. Michigan St., Indianapolis.
IOWA	Code of Iowa, Chapter 323, Requirements for Sanitation and Ventilation of Single Family and Multiple Dwellings. Code of Iowa, Chapter 73, Ventilation Requirements in Industrial Establishments Pertaining to Health and Safety. Department of Public Instruction Rules Relating to Heating and Ventilating of School Buildings.	Dept. of Health, Div. Public Health Engr. and Industrial Hygiene, Des Moines.

CHAPTER 48. ABBREVIATIONS, SYMBOLS, STANDARDS

TABLE 4. STATE CODES, STANDARDS OR LAWS RELATING TO THE HEATING, VENTILATING OR AIR CONDITIONING OF BUILDINGS—(Continued)

STATE	CODES, STANDARDS OR LAWS	WHERE MATERIAL CAN BE OBTAINED
KANSAS	Matter is left to judgment of safety engineer inspector. See Labor Laws of Kansas (1940), G. S. 1935, 44-636.	Labor Department, 801 Harrison, Topeka.
KENTUCKY	Statutes of Kentucky: Section 2060b-1 provides for the proper ventilation of food establishments; Sections 2739-19, 2739-24, 2739-37, and 2739-42 provide for the proper ventilation of mines.	Secy. of State, Frankfort.
LOUISIANA	None.	
MAINE	Regulations bearing on this subject in reference to the installation of plumbing fixtures in closed rooms are outlined in Sections 101 and 102 of the State Plumbing Code. Rules and Regulations Relating to Sanitation of Factories and Mercantile Establishments include Sections on Ventilation.	Division of Sanitary Engineering, Dept. of Health and Welfare, State House, Augusta.
MARYLAND	Standards for Maryland School Buildings, Revised, 1941.	State Dept. of Education, Annapolis.
MASSACHUSETTS	Laws Relating to the Erection, Alteration, Inspection and Use of Buildings (Form A); Regulations Relative to the Inspection of Buildings Which Are Subject to the Provisions of Chapter 143, General Laws (Form B-1).	Dept. of Public Safety, Division of Inspection, 3 Hancock St., Boston.
MICHIGAN	Housing Law of Michigan (1939).	Secretary of State, Capitol Bldg., Lansing.
MINNESOTA	Laws Relating to Sanitation, Ventilation and Toilets in Factories, etc. Also requirements in regard to garages, spray rooms and spray booths.	Industrial Commission, State Office Bldg., St. Paul.
MISSISSIPPI	None.	
MISSOURI	State Labor and Industrial Inspection Laws (1941).	Dept. of Labor and Industrial Inspection, State Office Bldg., Jefferson City.
MONTANA	Revised Codes of Montana (1935), Section 1175 refers to ventilation of school buildings.	Secretary of State, Helena.
NEBRASKA	Safety Codes (1937) and Labor Laws (1941).	Dept. of Labor, Lincoln.
NEVADA	Nevada Compiled Laws (1929), Sections 5894 and 5715 pertain to School Buildings. Compiled Labor Laws (1937), Part 14, Section 4241 Ventilation of Mines; Part 8, Sec. 2817 Ventilation Bunk Houses.	Secretary of State, Carson City.
NEW HAMPSHIRE	Under the provisions of Chapter 177 of the Public Laws, Safety and Health of Employees, recommendations are made in mills, factories, workshops, commercial and mercantile establishments for proper ventilation.	Bureau of Labor, Concord.
NEW JERSEY	Industrial Code Bulletins and Labor Laws.	State Dept. of Labor, Wallach Bldg., Trenton.
NEW MEXICO	Regulations Governing the Heating and Ventilation of Tourist Courts, Tourist Camps, Hotels and Lodging Houses (1939).	Dept. of Public Health, Santa Fe.
NEW YORK	Commissioner of Education is authorized to determine the requirements for proper ventilation of school buildings. Codes are enforced by the Department of Labor which contain sections on ventilation requirements pertaining to a number of industrial processes, such as: No. 10 Foundry Code; No. 12 Dust, Fumes and Gases; No. 32 Automobile Spray; No. 33 Rock Drilling; No. 34 Stone Crushing; No. 35 Stone Cutting and Finishing.	Commissioner of Education, Albany. Secretary, Labor Dept., 80 Centre St., New York.
NORTH CAROLINA	Building Code (1936) Chapter 14, Heating and Mechanical Ventilation, Experiment Station Bulletin No. 10.	North Carolina State College, Raleigh.

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TABLE 4. STATE CODES, STANDARDS OR LAWS RELATING TO THE HEATING, VENTILATING OR AIR CONDITIONING OF BUILDINGS—(Concluded)

STATE	CODES, STANDARDS OR LAWS	WHERE MATERIAL CAN BE OBTAINED
NORTH DAKOTA	None.	
OHIO	Ohio State Building Codes: No. 102 Theaters and Assembly Halls (1940); No. 103 School Buildings (1938); No. 105 Churches (1938); No. 106 Hospitals and Homes (1936); No. 107 Hotels and Apartments (1940); No. 108 Public Garages (1938); No. 109 (1941); Workshops, Factories, Mercantiles and Office Buildings.	Dept. of Industrial Relations, Div. of Factory and Building Inspection, Columbus.
OKLAHOMA	Bureau of Factory Inspection Bulletin No. 7-A, containing the laws governing the inspection and regulation of factories or other places where labor is employed. Bureau of Factory Inspection Book No. 11-A—Petroleum Industry Safety Standards.	Dept. of Labor, Oklahoma City.
OREGON	None.	
PENNSYLVANIA	Regulations For: Abrasive and Polishing Wheels; Brewing and Bottling; Canneries; Cereal Mills. Malt Houses and Grain Elevators; Construction and Repairs; Dry Color Industry; The Storage, Handling and Use of Explosives; Foundries; Industrial Sanitation; Regulations for Labor Camps; Laundries; Lead Corroding and Lead Oxidizing; Logging, Sawmill, Woodworking, Veneer and Cooperage Operations; Mines Other Than Coal Mines; Miscellaneous Hazards and Conditions of Employment; the Manufacture of Nitro and Amido Compounds; Plants Manufacturing or Using Explosives; Printing and Allied Industries; Spray Coating; Tunnel Construction and Work in Compressed Air.	Dept. of Labor and Industry, Harrisburg.
RHODE ISLAND	Law Governing Safety and Health in Buildings and Factories (1940).	Dept. of Labor, State House, Providence.
SOUTH CAROLINA	None.	
SOUTH DAKOTA	State Code, Chapter 13.2018 Care of Steam Boilers; Chapter 27.1711 Ventilation of Hotels, Rooming Houses, Restaurants, Tourist Camps.	Office of State Engineer, Pierre.
TENNESSEE	Williams Code of Tennessee, Sections 5341-5343, which deal with the ventilation of workshops and factories, places of amusement, etc.	Secy. of State, Nashville.
TEXAS	School Building Law, Bulletin 382, February, 1938.	Dept. of Education, Austin.
UTAH	None.	
VERMONT	Public Laws Rules and Regulations Relating to Public Buildings, Sanitation, Plumbing, Heating and Ventilation (1941).	State Board of Health, Burlington.
VIRGINIA	Mining Laws of State of Virginia have provisions regarding ventilation in mines.	Dept. of Labor and Industry, Finance Bldg., Richmond.
WASHINGTON	General Safety Standards: Standard No. 45 Blower and Exhaust Systems; No. 46 Respirators, Helmets, etc.; No. 47 Carbon Monoxide Gas; No. 202 Ventilation; No. 210 Laundry Ventilation; No. 218 Dry Cleaning with Volatile, Inflammable or Explosive Liquids. Coal Mining Laws; Occupational Disease Code; Metal Mine Standards; Safety of Persons Employed in Tunnels, Quarries, Caissons or Subways; Construction Code.	Dept. of Labor and Industries, Olympia.
WEST VIRGINIA	Installation Regulations for Power Boilers.	Dept. of Labor, Charleston.
WISCONSIN	Heating, Ventilation and Air Conditioning Code (1939). Applies to public buildings and places of employment. General Orders on Dusts, Fumes, Vapors and Gases (1941).	Industrial Commission of Wisconsin, Madison.
WYOMING	None.	

EMERGENCY WAR PRACTICES

INFORMATION given in the Technical Data Section of the GUIDE is based on standard and commonly accepted good practices. Due to war conditions and in order to save critical materials for war service, many substitutions in materials and changes in methods have been necessary. The purpose of this supplement is to indicate some of these practices¹ used during 1942 to meet the conditions imposed by war.

Regulations by the U. S. War Production Board have banned the manufacture, installation and sale of heating, ventilating, air conditioning and refrigeration equipment of almost all kinds except for essential war and civilian use. Interpretation of the regulations discloses that all air conditioning for personal comfort is eliminated, and equipment for supplying preference orders only can be made available. In this way, the most essential needs of the war program, by virtue of their high priority rating, have first access to whatever equipment is available. Provision has been made for securing materials to permit emergency repair services to be rendered on existing equipment.

Physiological Principles

1. Due to the necessity of conserving fuel, attention has been directed toward the possibility of relaxing the A.S.H.V.E. winter optimum comfort standards of 66 deg effective temperature during the emergency. In a report² submitted to the Fuel Rationing Division of the U. S. Office of Price Administration, in September, 1942, a group of medical and public health authorities suggested minimum temperatures for emergency requirements, subject to local, state and municipal regulations or codes, as listed herewith in dry-bulb temperatures:

a. For the average private home, 60 to 68 F (majority opinion 65 F).

b. For the average apartment house, 60 to 68 F (majority opinion 65 F).

c. For hospitals and sanatoriums, 68 to 80 F (majority opinion 70 F, except operating rooms 80 F).

d. For schools, 60 to 70 F (majority opinion 65 F).

e. For department stores, office buildings, etc., 60 to 68 F (majority opinion 65 F).

2. Ventilation standards that have been recognized for many years are not being observed. In the case of schools, auditoriums and other places of public assemblage, where design standards of not less than 10 cfm per person of outside air have been previously used, it has been common practice to reduce this outside ventilation rate to 5 cfm per person. Air changes for toilets, locker rooms, rest rooms and kitchens have been reduced. The use of exhaust fans has been curtailed in favor of gravity or window ventilation wherever possible.

¹Compiled from information furnished by consulting engineers, manufacturers and trade association representatives.

²Medical and Public Health Aspects of Heating Oil Rationing, by L. D. Bristol, M.D. (A.S.H.V.E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, October, 1942, p. 627).

Heating Load

In the spring of 1942, the War Service Committee of the Society was appointed and immediately focused attention upon the importance of fuel conservation as a war measure³ and recommended a program which included Ten Ways to Save Fuel and Improve Heating Plant Efficiency which are enumerated herewith:

Fuel saving percentages are based on the total heat loss of a typical two-story detached residence⁴ without storm windows, insulation, or other fuel conservation measures, and are not necessarily cumulative but will often total 60 per cent in practice if all precautions outlined are adopted.

1. INSTALL STORM WINDOWS AND DOORS

- a. Application of storm windows and doors will save from 20 to 25 per cent.

Tightly-fitting storm sash enables the maintenance of higher indoor relative humidities without window condensation. Reduces down-draft of cold air at windows and together with increased glass surface temperature improves comfort of the occupant. The addition of humidity permits a reduction in dry-bulb temperature for equivalent comfort conditions, but this condition does not result in fuel saving.

If you want to install storm windows and doors, call your builder, lumberman, hardware dealer, or window manufacturer, who will give you an estimate of the cost. Some dealers maintain a stock of standard sized windows, which can be fitted to your window with a minimum of work. It is advisable to have the storm windows installed with hinges so that they can be partially opened during mild weather, and also to facilitate cleaning. However, when the storm windows are closed they must fit tightly against the window frame to be effective. A strip of felt placed in this joint will prevent air leakage.

The locks on the inside windows should be closed, as these tend to pull the windows tighter. If condensation appears on the

inside of storm windows it may be necessary to bore a small hole in the bottom of the sash to allow for the entrance of a small quantity of air between the windows.

In the case of those windows where the introduction of light is not important, it is possible to nail panels of rigid insulation board to the window sash, or make such panels easily removable. A cloth window shade fully drawn at a window, or the pulling of window length drapes across the window, will also materially reduce the heat loss through a window.

2. INSULATE YOUR HOME

- a. Ceiling insulation will save from 10 to 15 per cent.
- b. Wall insulation will save from 12 to 20 per cent. Application of insulation will improve inside wall surface temperatures, thus increasing the comfort conditions.

Call an insulating contractor and have him prescribe the proper treatment and give you an estimate of the cost. One method of insulating an accessible attic is to blow loose fill insulation evenly spread to a depth of several inches into the space between the rafters; another is to apply batts or blanket insulation; and another is to apply rigid insulation boards.

To apply wall insulation to an existing structure, it is generally necessary to use a loose fill insulation, which may be poured or blown into the outside walls by removing sections of clapboards, brick, or other exterior materials.

3. ADD WINDOW AND DOOR WEATHERSTRIPPING

- a. Installation of weatherstripping will save from 5 to 10 per cent. Savings are greater when applied to loose-fitting windows and doors.

There are weatherstripping contractors and dealers who are equipped to make proper installations. Partial results can be obtained by the use of felt strips tacked on the upper and lower sash, where they come in contact with the window frame.

In case there may be some windows in the house that can be permanently closed for the winter, it is possible to caulk the openings with strips of heavy cotton cord or similar material. Also, inexpensive tape can be applied as a seal around all the cracks of the window to prevent infiltration.

Air leakage can also be reduced by calking cracks around windows and door frames, which have been caused by the gradual shrinkage of the wood frame from the exterior building materials or concrete foundation. This is an important item in your fuel saving program.

4. AVOID OVERHEATING

- a. Install thermostatic control for the maintenance of uniform temperatures between 65 and 70 F, and adapt suitable clothing for comfort at these temperatures.

³War on Fuel Waste Week—Fuel Conservation (A.S.H.V.E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, September, 1942, p. 558). War on Fuel Waste, by B. M. Woods (A.S.H.V.E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, November, 1942, p. 699). See also War on Fuel Waste—How To Do It published by A.S.H.V.E. and available in pamphlet form.

⁴The heat losses through a typical two-story residence will be distributed approximately as follows: 30 per cent through the side walls of the house, 26 per cent through the windows and doors, 20 per cent through air leakage, 15 per cent through ceilings and roof, and 9 per cent through the floors. Percentage values abstracted from paper—Automatic Gas Burners, by C. G. Segeler (A.S.H.V.E. TRANSACTIONS, Vol. 38, 1932, p. 548).

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If you have a thermostat, be sure that it is functioning properly and that it is located at some place in the house, where it is not subjected to unusual cold drafts. Good controls can be adjusted to operate automatic firing equipment, so as to maintain room temperatures within one degree above or below the thermostat setting. If you convert your heating plant from oil to coal, have your thermostat arranged so that it will operate the draft dampers on the boiler or furnace.

5. LOWER TEMPERATURES

- a. Reduce temperatures at night to about 60 F and fuel savings will range from 5 to 10 per cent.

If the thermostat setting is lower than 60 F, fuel savings will diminish due to the necessity of reheating the house from an abnormally cold condition. Reducing the temperature from 72 F at 10:00 p.m. to 66 F and bringing temperature back to higher level at 5:30 a.m. made a saving of 10 per cent of the total fuel used in a test house⁸.

- b. When away for a weekend or several days set the thermostat at about 50 F which will prevent damage from freezing.

6. DO NOT HEAT UNUSED ROOMS

- a. Disconnect or turn off the heat in the garage for the duration of the war. In the case of steam, this can be done by merely turning the valve to the radiator. With hot water heating systems, there is still a small circulation of water through the radiator even though the valve is closed and it is therefore necessary to disconnect the radiator and plug the pipe branches at some place within a heated space to avoid freezing. Drain radiator carefully.
- b. Most sun rooms have an excessive amount of heat loss due to the number of windows and for that reason it is recommended that the radiators in these rooms be disconnected. Then, tightly seal this room from the rest of the house by the use of doors or the application of panels of insulating board.
- c. As all warm air tends to rise, it is important to keep all doors and hatches tightly closed to attic spaces and unused rooms. If you are in the habit of opening bedroom windows for sleeping, be sure and turn off the heat and close the doors to the warm portions of the house. In most cases, a window raised from 6 to 10 in. will provide all the cooling and outside air needed at night in a bedroom.
- d. All fireplaces burn fuel inefficiently, but during the mild seasons of the year they can be used for necessary warmth instead of turning on the principal heating plant for the residence. When a fireplace is not in use, it

should be properly sealed, or the dampers should be closed tightly to prevent the loss of heat up the chimney from other sources in the house. Many fireplaces have no dampers.

- e. Avoid keeping all outside doors open or standing and talking in an open doorway.

7. INSULATE HOT WATER HEATER

- a. If your hot water storage tank is bare, call your local heating contractor and have an adequate amount of insulation applied to conserve heat. This should be done even though an auxiliary heater such as electricity or gas is used to heat the hot water.
- b. Call the plumber immediately and have him repair all leaky hot water faucets, because this wastes both water and fuel.

8. IMPROVE RADIATOR EFFICIENCY

- a. Purchase an inexpensive long handled brush and remove all the dirt collections in the pockets of the radiators. If possible, remove the fronts or cabinets of all convectors and clean all the dirt deposits in the radiator unit. With closely spaced fins in the radiator section of some convectors, obstructions such as dirt will reduce the air circulation to the extent that the efficiency is seriously impaired.
- b. It is important to keep heavy drapes and curtains away from all radiators and the outlet grilles of convectors, because they restrict the free circulation of air over the unit. Homemade wooden shelves and grilles surrounding or partially enclosing radiators act in some cases like dampers and should be removed or replaced with a correctly designed radiator shield or enclosure. A properly designed cover or shelf over the top of a radiator will deflect the heated air and prevent it from immediately rising.
- c. Many radiators have been painted with bronze and aluminum finishes. The application of ordinary oil paints to such radiators will improve their efficiency as much as 10 per cent.
- d. Place a surface having a high reflectivity behind each radiator which will reflect the heat back into the room that is normally absorbed in the wall at this point.

9. CHECK FURNACE COMBUSTION EFFICIENCY

- a. Removal of soot from inside surfaces of furnace or boiler will save about 5 per cent. Soot accumulation clogs the passages and reduces the draft. The soot and fly-ash located on the inside of a furnace or boiler can be removed with a long handled stiff wire brush. Also the smoke pipe connection between the furnace or boiler and the chimney should be taken down and the soot removed. It is a good plan to clean the chimney if this has not been done for some time and be sure and remove the soot dislodged from the chimney through the cleanout door at the chimney base.

⁸Operation of the Research Home with Reduced Room Temperatures at Night, by A. P. Kratz, W. S. Harris and M. K. Fahnestock (A.S.H.V.E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, December, 1942, p. 743).

- b. The furnace combustion efficiency should be checked with scientific instruments by your heating contractor or burner dealer. The three important indicators of good combustion are chimney draft, stack temperature in degrees Fahrenheit, and percentage of carbon dioxide in the flue gas. A *poor* operating oil burner unit may have a stack temperature as high as 800 F with the carbon dioxide around 5 per cent. A *good* operating oil burner should have a stack temperature of approximately 450 F with a carbon dioxide content of 10 per cent.

10. RECONDITION HEATING PLANT

- a. Many home owners are unknowingly wasting fuel in their heating plants at the present time and for that reason a competent heating contractor should be obtained to survey and test the installation. Frequently an inefficient apparatus can be repaired or adjusted at a small charge with resulting fuel savings that will more than compensate for the expenditure within a short time.
- b. The thermostatic control equipment including the room thermostat, limit controls, water temperature regulator, safety devices, low water cut-out, etc., should be carefully inspected and adjusted for efficient operation.
- c. If there are cracks or pieces of insulation loose on the boiler or piping, they should be repaired or replaced. Have the radiator air valves either cleaned, repaired or replaced, as the contractor recommends. It is also a good idea to have all of the steam radiator traps checked for efficient operation and the radiator valves packed in case it is necessary. Some radiators become air bound from operation and these should have the air purged from them.
- d. In a warm air furnace system it is important to have the air filter in the proper condition, as a dirty unit will increase the air resistance. To alleviate this condition the filter should be removed and inspected. In some cases a vacuum cleaner may be used to remove the superfluous dirt from the outside surface of the filter. Make sure that all of the air supply and return grilles are open and unobstructed, so that the air will be circulated to all of the intended portions of the house. In case there is an outside air intake, it should be closed off for the duration.

Combustion and Fuels

To supplement the *Ten Ways to Save Fuel and Improve Heating Plant Efficiency*, the A.S.H.V.E. War Service Committee also outlined several suggestions for the hand firing of coal in those residential heating plants which could be converted from automatically fired oil or gas:

1. The furnace grate area and the depth to which the coal is fired are the two governing factors

in the selection of size of coal. Consult the directions provided by the manufacturer of the boiler or furnace, or your coal dealer for the proper size and kind of fuel to be used. Do not wet the coal before burning it. Garbage or rubbish should not be burned in the heating system.

2. Leave from two to three inches of ashes on the grate at all times for protection against excessive heat and to prevent unburned coal falling through. Coal should be heaped as much as possible against the rear or side walls of the firebox so that a portion of the glowing fuel is always left exposed to ignite the gases. Keep the firebox filled to a level with the bottom of the firing door. Avoid poking or punching holes in the fire.

3. After fire is started the turn damper in the smoke pipe should be nearly shut at all times. Control the fire with the check damper in the smoke pipe and the ash-pit damper. For moderate heating requirements, open check damper wide and close ash-pit damper. As additional heat is required close check damper partially or fully and open ash-pit damper similarly. The damper in the fire door should be slightly open at all times. Do not leave fire door open as this wastes coal. The ash-pit doors and draft slide should fit tightly.

4. Do not shake the fire unnecessarily. Stop shaking when the first red glow appears in the ash-pit. Wet ashes thoroughly and remove just before next shaking. Do not allow ashes to accumulate excessively in the ash-pit, as this shuts off the draft and may burn out the grates.

Automatic Fuel Burning Equipment

1. No automatic coal stokers having a capacity of 60 lb or less can be manufactured during the emergency. Larger stokers have been made available for converting big users of fuel oil to coal, when approved by the War Production Board.

2. The shortage of fuel oil has restricted the manufacture of oil burners, except on government preference order. It is possible to replace an existing oil burner in a residence, in case the need arises, providing the installation cannot be converted to coal.

3. The manufacture of automatic gas heating equipment has been restricted for the emergency. In case there is a need to replace an existing unit, the new installation may be the equivalent, but not a substantial improvement over the old installation.

Heating Boilers

1. Boilers of 10,000 sq ft of equivalent steam radiation and less have been con-

EMERGENCY WAR PRACTICES

structed of cast-iron to conserve on critical materials, and above this capacity steel has been permitted.

2. Due to the advent of the airplane, it has been found necessary to shorten the boiler stacks nearer the roof line, and use axial flow propeller type induced draft fans. These induced draft fans have been inter-connected to the automatic fuel burning control equipment.

3. Induced draft has been used more frequently on boilers to eliminate steel stacks and radial brick chimneys.

4. Smoke breechings of masonry have been used wherever possible instead of steel.

5. Some previous central boiler plants have been designed with units generating steam at 100 lb per square inch. Steam at this pressure has been distributed to the several buildings on the system, with reducing pressure valves located at each building to take care of individual requirements. Instead of this design, it has been the practice in some cases, to use relatively low pressure cast-iron boilers for heating in the central plant and two or more 50 lb boilers for providing the necessary sterilizing and process steam supply. This latter arrangement has necessitated a duplicate distribution system of piping with a consequent increase in poundage of metal for the whole installation, but an important saving has been made in critical boiler plate and reducing valves.

Radiators and Convectors

1. Cast-iron convectors or steel fin type radiation, instead of non-ferrous units, have been used.

2. Radiator and convector cabinets and enclosures of substitute materials, such as wood, plastic and rigid fiberboard have been fabricated.

3. Large-tube cast-iron radiators are not available during the emergency, and the manufacturers have limited the production of small-tube cast-iron radiators to the ten sizes listed:

NO. OF TUBES PER SECTION	CATALOG RATING PER SECTION SQ Ft EDR	HEIGHT INCHES
3 or equal.....	1.6	25
4 or equal.....	1.6	19
	1.8	22
	2.0	25
5 or equal.....	2.1	22
	2.4	25
6 or equal.....	1.6	14
	2.3	19
	3.0	25
	3.7	32

Steam Heating Systems

1. Radiator valve and trap bodies have been made of cast-iron instead of brass.

2. Plastic floor and ceiling plates have been used instead of metal plates.

Piping for Steam Heating Systems

1. Whereas steam supply mains for vacuum systems have been previously designed on the basis of a pressure loss of $\frac{1}{4}$ lb per 100 ft of equivalent run and an initial pressure of 1 lb or less, some designers have used a pressure drop of 1 lb per 100 ft and an initial pressure of 5 lb per square inch.

Pipe, Fittings, Welding

1. All valves 2 in. and larger have been made of iron throughout, without bronze seats, seat rings and spindles.

2. Uncoated wrought iron or steel pipe has been used in lieu of brass or galvanized iron wherever practicable.

3. Expansion loops have been used in distribution systems instead of expansion joints.

Gravity Warm Air Furnace Systems

1. Standardization of the sizes and shapes of ducts, boots, stackheads, registers, and return air grilles has been voluntarily effected by the manufacturers in which about 75 to 80 per cent of former listed

catalog items have been eliminated, with no detriment to the industry.

2. The design of heating plants for defense housing units has favored the use of a small number of short, large-sized return air ducts.

3. Furnace sizes have been limited to a top capacity of about 80,000 Btu per hour. Steel furnace production has been severely limited. Attempts are being made to reduce the number of sizes of furnaces manufactured by any company.

Mechanical Warm Air Furnace Systems

1. Trends toward simplification have eliminated entirely return ducts from the second floor. Returns from the first floor in a two-story building have been reduced, and in some cases are limited to one in the living room and one in the stair hall to return the air from the second floor.

2. Both supply and return ducts are fabricated from asbestos products and fiber boards or other substitute materials with metal clips to hold them together.

Central Systems for Comfort Air Conditioning

1. Brick and tile coil supports instead of channel irons have been advocated.

2. Columns and beams for the support of heating and ventilating equipment have been made of wood rather than of structural steel.

3. In view of the curtailment of refrigeration for cooling, a practice has been followed of arranging the outdoor air supply so that the percentage of outside ventilation air can be increased in summer weather. With this arrangement dampened relief openings are provided to allow the excess supply air to discharge outside the building.

Unit Heaters, Unit Ventilators

1. With the exception of the motor, fans, heating element and damper, unit ventilators have been made with the outer

casing and other parts constructed of wood and processed wood materials. As a result of this substitution, such units have used about one-third of the steel required in the same unit of all steel construction; or the equivalent of approximately one-half a pound of vital metal per square foot of delivered direct radiation.

2. The casings of unit heaters have been constructed of fiber board sheets instead of steel. Likewise steel has been substituted for the heating element instead of copper and aluminum which were formerly used.

3. Large direct-fired unit heaters burning coal, oil or gas with capacities in excess of 1,000,000 Btu per hour have been made available for heating large spaces. In some instances, the outer casings of these units have been constructed of $\frac{3}{8}$ in. asbestos cement board.

Unit Air Conditioners, Unit Air Coolers

1. The manufacture of small self-contained type air conditioners has been prohibited. Where government orders require such equipment substitute materials have been used in the fabrication of the casings and other parts.

Refrigeration

1. Welded steel refrigerant piping has been used instead of copper.

Heat Transfer Surface Coils

1. Instead of using copper or brass for heating and cooling coils, steel pipe either plain or with steel fins has been used.

Spray Equipment

1. Evaporative cooling has been used where indoor conditions can be maintained within the desired specifications.

2. The tanks of air washers have been constructed of wood and other substitute products.

3. Spray nozzles for air washers and other spray equipment have been made partially or completely of plastics.

Air Cleaning Devices

1. Wood frames have been used for air filters.

Fans

1. Inlet vane control with a single speed motor on fans has replaced the variable speed fan motor, and a control has been added for air volume adjustment.

Air Duct Design

1. Asbestos and processed wood board in lieu of galvanized or black iron and copper for ducts has been utilized.

2. Air ducts have been constructed of tongued and grooved wood, and intentionally oversized, so that at some future date it will be possible to line them with sheet metal.

3. A rigid insulation board faced on each side with a layer of at least $\frac{3}{16}$ in. thick cement asbestos has served the dual purpose of providing a fireproof as well as an insulated duct construction.

4. Blue annealed steel sheets have been used instead of galvanized steel for ducts.

5. There has been a trend toward the use of higher duct velocities in design.

6. Wooden trusses and hangers have been used for supporting the duct work.

7. Painted steel screens instead of brass or copper screens for air intakes is another substitute application that has been utilized.

8. A terra cotta tile flue set on an angle in the wall and wood have been used instead of metal louvers for air intakes. Roof intakes of wood have been constructed.

9. All nickel or chromium plating has been eliminated.

10. Felt has been used instead of sponge rubber for damper blades.

11. Paint has been used as a substitute for galvanizing on ferrous surfaces.

Sound Control

1. Felt has been substituted instead of cork for isolating coil casings, motors, etc.

Instruments and Test Methods

1. Gage boards have been constructed of wood rather than of steel.

Industrial Exhaust Systems

1. Instead of using scarce materials in acid resisting fans, plain steel has been used with a baked plastic coating.

2. Wherever possible, masonry housings have been built for acid proof fans to save high grade alloys previously employed.

Natural Ventilation

1. The housings for roof ventilators have been constructed of wood.

Pipe and Duct Heat Losses

1. Steel lacquered bands on pipe covering have been used in lieu of brass bands.

2. Asbestos, glass wool, expanded vermiculite, etc., have been used instead of 85 per cent magnesia type pipe covering.

3. Rock cork insulation has been utilized for cold air ducts or pipes instead of natural cork.

Water Supply Piping and Water Heating

1. Cement lined steel pipe has been used for cold water instead of brass or galvanized iron.

2. Wood pipe ranging in sizes up to 12 in. has been used for carrying water under pressures of 100 lb per square inch.

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HEATING, VENTILATING AND AIR CONDITIONING

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The

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Alphabetical listing of advertisers—on pages 875-880—permits ready reference to the products of a specific manufacturer.

For convenience in locating manufacturers' data on various types of apparatus and materials, the equipment shown in the Catalog Data Section has been grouped as follows:

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AIR CONDITIONING

●

Equipment for complete air conditioning systems, consisting of an assembly of apparatus for air circulation, air cleaning and heat transfer, with control apparatus for maintaining temperature and humidity within prescribed limits, has many commercial, comfort, and industrial applications. Systems for all-year, winter and summer service, and special processing work are presented in four divisions . . . Pages 883-928.

CENTRAL SYSTEMS (p. 883-896)

Complete assembly of supply and return ducts serving one or more spaces, connected with some or all of the following equipment: fans, motors, heat transfer surfaces, humidifiers, dehumidifiers, refrigeration machinery, air cleaning devices and control equipment.

An outline of the design procedure generally used to create a modern central air conditioning system is given in Chapter 21 of the Technical Data Section.

DIRECT FIRED UNITS (p. 897-905)

Automatic heating and comfort air conditioning apparatus suitable for residential and small commercial applications designed to give results similar to the larger central systems provide direct fired oil, gas or coal heating units, filtration, fan controls, etc.

The Technical Data Section, Chapters 12, 19 and 20 cover this type of equipment.

FAN-FURNACE SYSTEMS (p. 897-905)

Winter air conditioning and summer ventilation for residences are provided by Automatic fired fan-furnace systems. As in the larger central systems these installations clean, heat and humidify the air, and if desired, auxiliary units will provide cooling.

In Chapter 20 on Mechanical Warm Air Furnace Systems will be found details of the design of this type of system.

UNIT HEATERS, COOLERS (p. 906-928)

For complete or partial air conditioning there are a variety of self-contained units. Such units may be complete in themselves, employing their own direct means of air cleaning, heating distribution and source of refrigeration.

The various functional elements of unitary equipment are given in Chapters 22 and 23, for Unit Heaters, Ventilators, Humidifiers, Conditioning and Cooling Units and Attic Fans.

Manufacturer's products shown in this division are designed for specific applications. Consult the Index to Modern Equipment for additional products of these manufacturers.

Air & Refrigeration Corporation

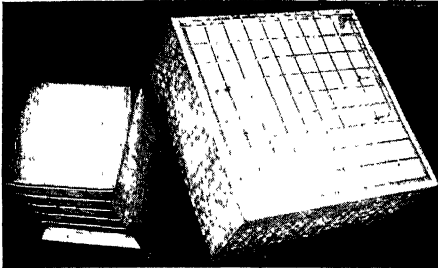
475 Fifth Avenue, New York City

Atlanta, Ga.

Detroit, Mich.



CAPILLARY AIR CONDITIONERS



*A standard Capillary cell with cut-away section showing oriented glass filaments.
Size: 20 in. x 20 in. x 8 in.*

Every Air Conditioning Engineer and all Industrial Engineers responsible for air conditioning should be familiar with the uses of this advanced equipment.

The standard Capillary cell is the basic element in all Capillary conditioners. The patented arrangement of glass filaments, essentially parallel to the flow of air and water through the cell, accounts for the highly efficient heat transfer between air and water. At the same time, the cells act as an efficient air cleaner and the arrested dirt is continuously flushed from the cell.

As a simple air washer, humidifier or evaporative cooler, Class I Capillary conditioners call for the recirculation of only 3 gpm per 1000 cfm distributed over the cells at 6 lbs nozzle pressure. The saturation efficiency is 97 per cent. Less efficient spray washers require 15 gpm or more at 20 lbs nozzle pressure.

A single stage of Capillary cells equals or exceeds in cooling and dehumidifying capacity a 2 bank spray type dehumidifier.

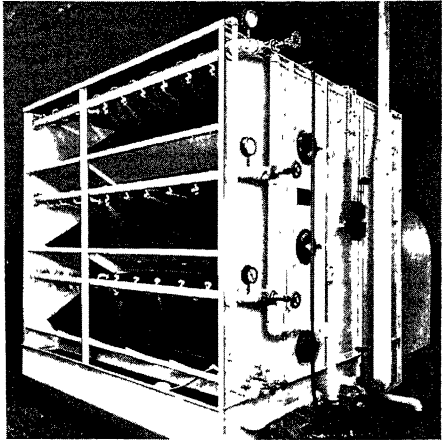
Increased cleaning efficiency and an approach of less than 1 deg F between leaving air and leaving water is obtained through a Class II Capillary wherein the water flows counter to the air through the cell.

A 2-stage Capillary Class I-II offers true counterflow performance with leaving cooling water temperature exceeding that of leaving air.

Where a closed system for the cooling medium is required (direct expansion,

Capillary conditioners used for cooling and dehumidifying save stragetic materials.

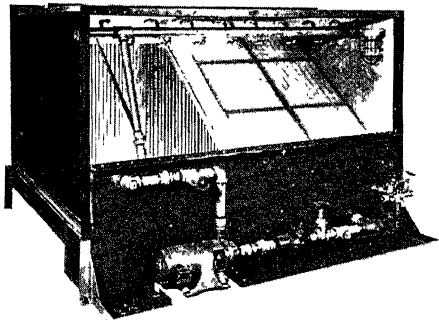
Submit design and capacity for specific recommendations or write for catalog and engineering data.



A standard Size 6-5 Class I Capillary Central Station Installation.

brine or cold water), a Class III Capillary is offered with suitable coils after the Capillary cells. No filters are required. Coils are kept clean and evaporative cooling is available whenever entering wet-bulb conditions permit.

Capillary conditioners of all classes are made in central station units ranging from 2200 cfm to 132,000 cfm or larger. Assembled units including fans, heaters, coils, pump, insulated casing, etc., suitable for suspension or floor mounting range from 4000 to 16,000 cfm.



A standard Size 3-4 Capillary unit air conditioner complete in insulated casing Capacity 16,000 cfm.

American Blower Corporation

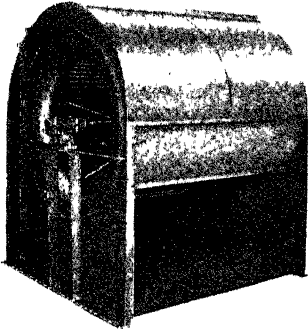
Division of American Radiator and Standard Sanitary Corporation

General Offices and Factory

Detroit, Mich.

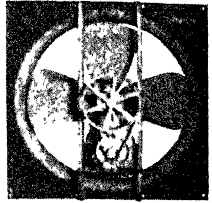
Branches in All Principal Cities

**AIR CONDITIONING — HUMIDIFYING — DEHUMIDIFYING — COOLING
— VENTILATING — HEATING — VAPOR-ABSORPTION — DRYING — AIR
WASHING AND PURIFICATION — EXHAUSTING EQUIPMENT AND
MECHANICAL DRAFT APPARATUS**

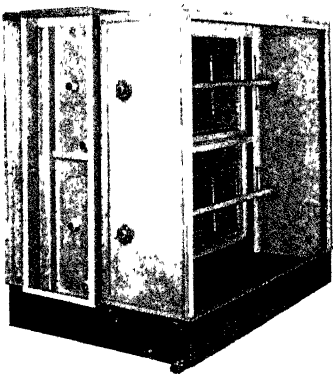
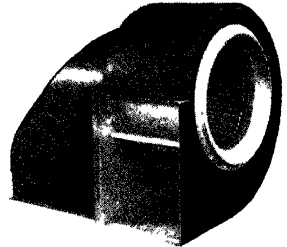


Double Inlet "ABC" Multiblade Fan—above, is a heavy duty ventilating fan. Its wheel has narrow, forward pitched blades. Low tip speeds assure quiet operation. Request Bulletin A-701. Write for Bulletin A-403 for backwardly inclined, non-overloading H. S. Fan.

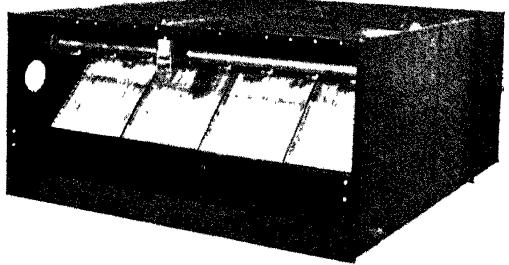
Commercial V-Belt Drive Ventura Fans—for ventilating applications without duct systems, where extremely quiet operation is desired. Inlet-outlet streamlined for high efficiency. Also direct connected. Request Bulletin B-2529.



"ABC" Utility Sets—right, complete packaged units, direct connected or V-Belt short coupled drive, for duct applications. Famous "ABC" Multiblade Wheel operates at low tip speeds. Quiet, compact. Bulletin B-2529.



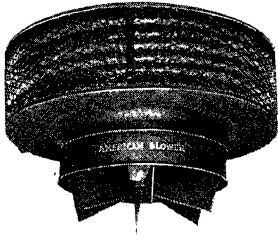
American Blower Air Washer—above, cleans, purifies and freshens the air, removes dust, odors and bacteria, cools if desired and provides an effective method of controlling humidity. Bulletin 3623.



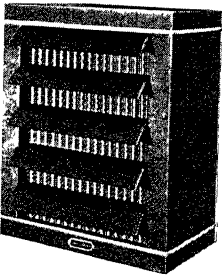
American Blower Capillary Air Washers—above, for high efficiency in cleaning, humidification, cooling and dehumidification of air. A highly efficient surface contact mechanism, the capillary cell, is used. Air is forced at low resistance through long, irregular passages of small size formed by a large amount of thoroughly wetted glass surface. Unit includes a substantial metal casing and tank of air washer design, capillary cells, improved low head sprays, metal or glass fibre low resistance moisture eliminators, non-ferrous, extended surface cooling or heating coils. Write for Bulletin 3723.

**TYPES OF AMERICAN BLOWER CORPORATION
AIR HANDLING AND CONDITIONING EQUIPMENT**

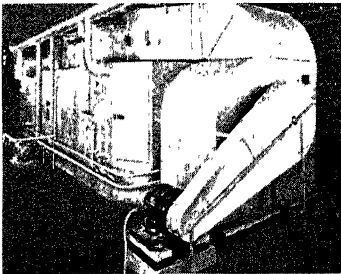
All types of air handling and air conditioning equipment for industrial applications, process work, drying, cooling; also equipment for stores, offices, shops, public buildings, power plants, etc., and attic ventilation for homes.



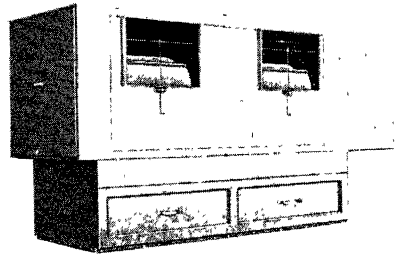
"ABC" Vertical Heaters—for ceiling applications, give an even, wide floor area distribution of heat. For either steam or hot water heating systems. Variable speed, 2-speed and constant speed models. Write for Bulletin A-9418.



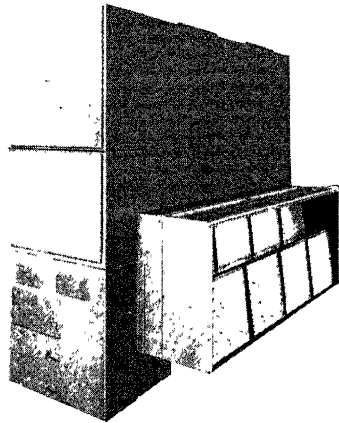
Venturafin Unit Heaters—for many general purpose heating jobs. Wall or ceiling mounting. Streamline construction, rugged heating elements. Steam or hot water. Write for Bulletin A-8218.



Air Conditioning Central Systems—provide an effective way of cooling, heating, humidifying, dehumidifying and purifying air in all classes of business and public buildings where a dust system is desirable. Write for Special Data.



"HV" General Purpose Units—with air filters and Aileron control. Ideal wherever attractive, quiet and economical heating and ventilating units are required. Wall, floor or ceiling mounting. Offer great flexibility of design and arrangement to meet specific needs. Write for Bulletin 5927.



American Blower Series "H" Air Conditioners with Sprayed Coils—are usually applied for industrial uses where air washing and evaporative cooling are required. Sprayed coils give cleaner air, cut coil maintenance and refrigeration costs, reduce necessary air volumes, permit use of smaller ducts and grilles. Horizontal or floor types (as shown). Aileron control provides simple method of regulating flow of air from the fans. Write for Bulletin 6027.

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ST. LOUIS
SAN FRANCISCO
WASHINGTON

AIR CONDITIONING

Room Air Conditioning and Refrigerating Unit—Self Contained.

Commercial Air Conditioning and Refrigerating Unit—Self Contained.

Air Conditioning and Refrigerating Assembly—With ducts

Room Air Conditioning Unit—for Central Station System -Normal Ducts.

Room Air Conditioning Unit—for Central Station System -Conduit air Distribution.
Cooling range .4 to 1.3 tons. Heating range 2000 to 34,500 Btu per hour.

Room Outlet—for exposed or concealed ducts.
Air capacity 40 to 4900 cfm per outlet.

Commercial Air Conditioning Units—Suspension No Ducts.
Cooling range .5 to 5.5 tons. Air capacity 310 to 1850 cfm.

Commercial Air Conditioning Units—Floor Mounted With Ducts.
Cooling range 2 to 45 tons. Heating range 100,000 and up Btu per hour.
Air capacity 700 to 8000 cfm.

Commercial Air Conditioning Units—Suspension -With ducts.
Cooling range 2 to 45 tons. Heating range 100,000 and up Btu per hour.
Air capacity 700 to 8000 cfm.

Industrial Air Conditioning Unit. May be installed with or without ducts.
Cooling range 2 to 45 tons. Heating range 30,000 to 750,000 Btu per hour
Air capacity 2000 to 8000 cfm.

Industrial Humidifier—humidifiers, filters, distributes air.

Dehydration—silica gel. For either residential or industrial applications.
Four sizes: Moisture removal capacity 23 to 125 lb per hour.

Heat Interchangers—air-to-water heating or cooling.
Two Types Available. Continuous tube and narrow width type.

Cold Diffusing Unit—Suspended -Disc Type Fan. Adjustable louvers.

Cold Diffusing Unit—Floor Mounted—Centrifugal Fan. Top or side discharge.

Cold Diffusing Unit—Floor Mounted—Centrifugal Fan -Brine Spray.

AIR CONDITIONING'S *First Name* **Carrier**

REFRIGERATION

Centrifugal Refrigerating Machine. Self-contained—cooler, compressor, condenser.
Wide range of sizes Cooling range 100 to 1200 tons.

Reciprocating Refrigerating Machine. Air-cooled, water-cooled, evaporative cooled.

Evaporative Condenser—Floor Mounted. For economical heat disposal.
Nominal range 10 to 75 tons.

Non-Freeze Coil—Available in sections, wide range of capacities.

Commercial Refrigeration—Storage refrigerators, display cases, milk coolers, ice makers, bakers refrigerators, and drinking water coolers in wide ranges of sizes and capacities.

UNIT HEATERS and WAR PLANT VENTILATORS

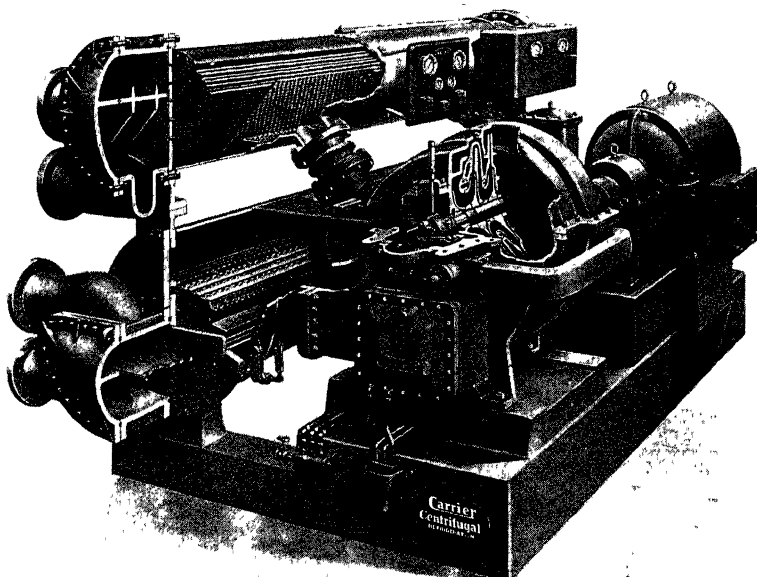
Unit Heater—Suspended—Disc Fan. For commercial or industrial buildings.
Heating range 19,450 to 106,000 Btu per hour. Air capacity 595 to 1395 cfm.

Five-Way Unit Heater—Suspended. For industrial heating.
Heating range 69,100 to 484,000 Btu per hour. Air capacity 1345 to 9245 cfm.

Heat Diffusing Unit—Suspended—Centrifugal Fan. For industrial service.
Heating range 280,000 to 950,000 Btu per hour. Air capacity 9000 to 16,000 cfm.

Heat Diffusing Unit—Floor Mounted—Centrifugal Fan.
Heating range 280,000 to 950,000 Btu per hour. Air capacity 9000 to 16,000 cfm.

Ventilators for War Plants—Roof Type for exhausting, supplying and tempering air in war plants. Capacities 10,000, 15,000 and 20,000 cfm.



NOTE: *Air conditioning has gone to war. Equipment is available only for those installations that are necessary in winning the war.*

Clarage Fan Company Kalamazoo, Michigan

Application Engineering Offices



In Principal American Cities

(Consult Telephone Directory)

CLARAGE AIR-HANDLING AND CONDITIONING EQUIPMENT

For Over a Quarter-Century Clarage has been a leading manufacturer of air-handling and conditioning equipment. There is a Clarage fan or blower, conditioning unit or system to meet every need, from the simplest ventilating or cooling job to the most exacting temperature and humidity control installation.

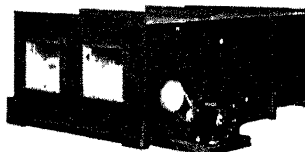
Whatever your ventilating, unit heating, cooling, drying, air cleaning, humiditying, dehumidifying, complete air conditioning or mechanical draft problem we can meet your requirements.

Clarage Experience covers every conceivable type of installation, commercial, industrial, public building and marine. Clarage equipment is used in the largest industrial plants, power plants, offices, theatres, hotels, restaurants, retail stores, hospitals, churches, schools and on thousands of ships.

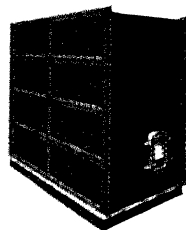
Help on War Problems: We're trying hard to maintain a prompt, intelligent war-time service--all the way through from initial recommendation to delivery. Write or phone for any desired information



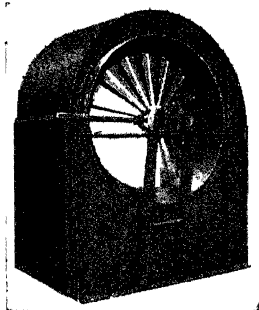
Clarage Systems for complete air conditioning in industrial plants and other buildings.



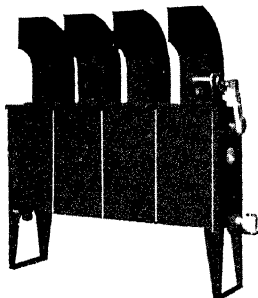
Multitherm Units for complete conditioning, cooling or heating.



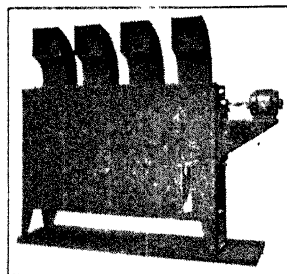
Unicool Units used in conditioning systems for air cleaning, cooling, heating and humidity control.



Clarage Fan with Vortex (constant speed) Volume Control for ventilation and air conditioning



Unitherm Unit Heaters with Syncrotherm Temperature Control for factory heating.



Unitherm Unit Coolers for product cooling and refrigeration.

Niagara Blower Company

General Sales Office: 6 East 45th Street, New York City

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BUFFALO: 673 Ontario St.

SEATTLE Fourth and Cherry Bldg.

District Engineers in Principal Cities

Over 25 Years' Experience in Industrial Air Conditioning, Liquid Cooling and Air Drying

NIAGARA AIR CONDITIONING SYSTEMS

For human comfort and for all industrial applications requiring controlled conditions of temperature, relative humidity, air purity and air movement.

NIAGARA AIR CONDITIONER, TYPE A

High precision apparatus using saturation to obtain control of R. H. to 1 per cent for laboratory work and control of hygroscopic materials. Ask for Bulletin 58.

NIAGARA AIR CONDITIONER, TYPE C

A year around air conditioning unit providing heating and humidifying or dehumidifying. Ask for Bulletin 80.

NIAGARA FAN COOLER AND DISK FAN COOLER

For comfort cooling, process cooling, low temperature storage for dairies, fruits, meats, food products, fur storage vaults, etc. Bulletins 72 and 78.

NIAGARA SPRAY COOLER

For all cooling applications requiring high humidity or high capacity in small space. Ask for Bulletins 72 and 78.

NIAGARA "NO FROST" SYSTEM

Using Niagara "No Frost" Liquid in spray coolers, prevents frosting of cooling coils, automatically keeps spray solution at proper concentration, gives freedom from brine troubles, corrosion. Constant, efficient operation. Temperature to -50°F . Ask for Bulletin 83.

NIAGARA EXTENDED SURFACE COILS

Encased for use with heating, cooling or air conditioning systems. Full range of sizes. Ask for Bulletin 92.

NIAGARA DUO-PASS AERO CONDENSER (Illustrated)

Saves power and water cost utilizing atmospheric air to remove heat of condensation. Patented Duo Pass prevents scaling, saves power. Ask for Bulletins 91 and 93.

NIAGARA "DUAL" COOLERS

Simultaneously cools a room and furnishes chilled water as a refrigerant.

Saves equipment cost, operating expense. Patented. Ask for Bulletin 70.

NIAGARA FAN HEATERS AND DISK FAN HEATERS

For heating and ventilating large areas. Units of the highest quality in engineering, material and workmanship. Ask for Bulletin 73.

NIAGARA AIR SUPPLY HEATER

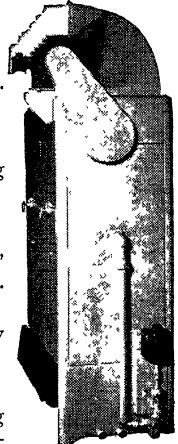
Balances exhausted air in factories when exhaust systems are operating, saves steam and power, gives more effective heating. Patent pending. Ask for Bulletin 74.

NIAGARA MOTOR BLOWERS

One, two and three-fan units. High and low static pressure models. Ask for Bulletin 89.

NIAGARA AERO HEAT EXCHANGER

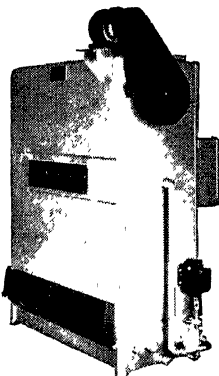
For cooling industrial liquids, water, oils, solutions, chemicals. Ask for Bulletin 90. Patented.



Niagara Spray Cooler



Concentrator for use with Niagara "No-Frost" System



Niagara Aero Condenser with Duo Pass

GENERAL ELECTRIC

AIR CONDITIONING AND COMMERCIAL REFRIGERATION DEPARTMENT

Bloomfield, New Jersey

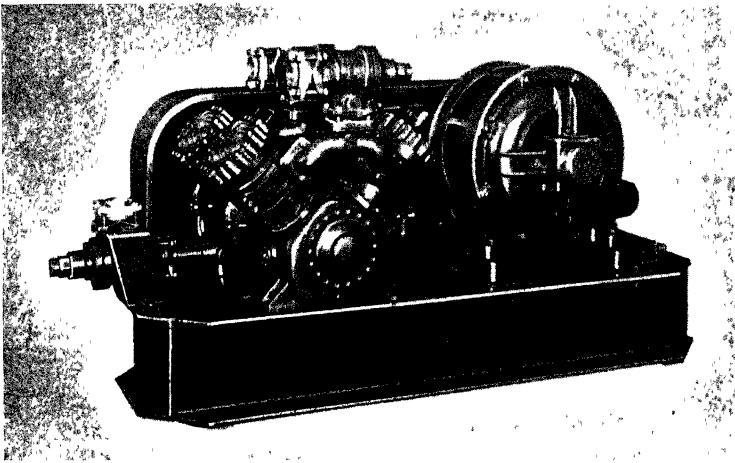
District Offices

ATLANTA, GA.
609 Red Rock Building
BOSTON, MASS
700 Commonwealth Avenue
CHICAGO, ILL.
840 South Canal Street
CLEVELAND, OHIO
4966 Woodland Avenue
DALLAS, TEXAS
1801 North Lamar Street
DETROIT, MICH.
700 Antoinette Street

MINNEAPOLIS, MINN
12 South 6th Street
NEW YORK, N. Y.
370 Lexington Avenue
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1105 Locust Street
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Terminal Sales Building
1220 Southwest Morrison
SAN FRANCISCO, CALIF.
235 Montgomery Street



A COMPLETE LINE OF STANDARD REFRIGERATION
PRODUCTS WHICH ARE AVAILABLE FOR ARMY,
NAVY, INDUSTRIAL AND OTHER ESSENTIAL USES



CONDENSING UNITS

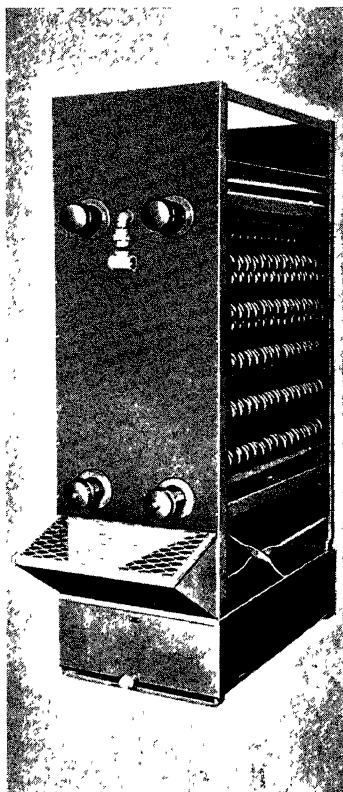
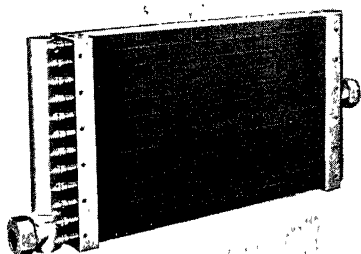
Applications: Low temperature refrigeration for food preservation in military cantonments, at advance bases and aboard ship. Also for applications in war industry where refrigeration is required for the processing and testing of war materials.

Product Data: G-E condensing units are available in a full range of standard sizes rated from $\frac{1}{4}$ to 125 horsepower. Modified units are available which permit multiple stage operation at temperatures as low as -140°F .

EVAPORATIVE CONDENSERS

Applications: Condensation of vapors, such as Freon 12 and steam; cooling of liquids . . . industrial or coolant oils, water, non-freeze mixtures, and other fluids used in industry.

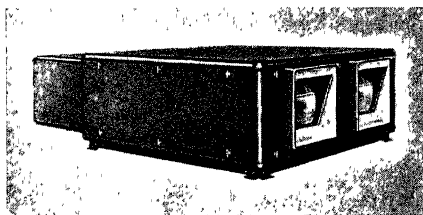
Product Data: Available in standard sizes which provide condensing capacities up to 60 tons of refrigeration with Freon 12. New nested coil assembly simplifies installation and also permits quick and easy disassembly for cleaning of scale and algae.



HEATING AND COOLING COILS

Applications: Ventilating systems, blast heating, industrial air conditioning, dehumidifying, refrigeration and cooling systems; special Army and Navy applications.

Product Data: Available in wide range of sizes to meet requirements of installation. Standard units of steel construction. Copper construction available where permitted by WPB regulations.



INDUSTRIAL CONDITIONERS

Applications: Industrial dehumidifying, cooling, heating; Army and Navy cantonments, storage, maintenance and special applications.

Product Data: Available in sizes ranging from 5 to 30 tons of refrigeration, with comparable capacities for heating service. Furnished for direct expansion of Freon 12 refrigerant, or for chilled water or cold well water. Heating coils use steam or hot water.

Parks-Cramer Company

Fitchburg, Mass.

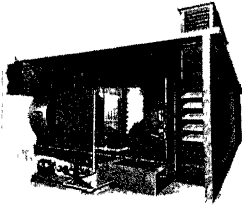
Charlotte, N. C.

CERTIFIED CLIMATE

Complete Air Conditioning Systems including Heating,
Cooling, Humidifying or De-humidifying, Air Changing,
Refrigeration, Air Filtering, Air Washing

AUTOMATIC REGULATION

Merrill Process System of Hot Oil Circulation for Heating Industrial Materials



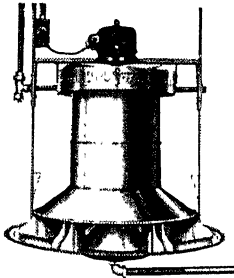
Central Station

Central Station Air Conditioning

Centrally located AIR WASHER. Proper moisture. Positive, pre-determined air removal or re-circulation. Heating coils and refrigeration optional. Helps such industries as Celluloid; Cement; Ceramics; Cereals; Cigars, Cigarettes and Tobacco; Clothing; Confectionery; Glassine; Leather; Paper and Envelopes; Printing and Lithographing; Shoes; Starch and Dextrine; Storage of Perishables; Textiles; Wood Products. Similar installations effective in Hospitals, Art Galleries, Auditoriums, Restaurants.

Air Washer or Central Station Units.

Nozzles for Central Station Air Washers.



High Duty Humidifier

High Duty Humidifier

Water under pressure generates spray. Excess water returns to filter tank and re-circulates. Evaporation per unit high; two sizes of heads each with three sizes of nozzles give flexible capacity for varying conditions. Circulation increased by individual motor-driven fan. Spray thoroughly diffused and distributed over wide area.

Turbomatic Humidifier

(not illustrated)

Efficient humidifier of the atomizer type. For direct humidification, as humidity boosters for Central Station systems of all makes. Self-cleaning.



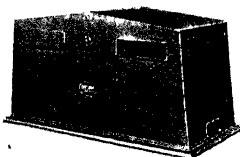
Psychrostat

Parks Automatic Airchanger

For use with High Duty or Turbomatic Humidifiers. Insures fixed humidity and maximum evaporative cooling.

Automatic Regulation

The Psychrostat for accuracy, durability, sensitivity. Employs the principle of the Sling Psychrometer, used in all U. S. Weather Bureau Stations. Hygrostat (not illustrated) where requirements are not so exacting. An Air Conditioning System is no better than its Regulation.



Pettifogger

The Pettifogger

A compact humidifier for offices, stores, storerooms, laboratories, or other isolated departments. Self-contained in lacquered copper casing. Permanently though flexibly connected to water and electrical supplies. Automatic control. Adjustable capacity. Reduces dust. Neutralizes drying effect of heating.

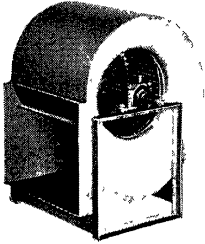
United States Air Conditioning Corporation

Heating, Cooling,
Ventilating and
Air Conditioning
Equipment



For Industrial,
Commercial and
Residential
Applications

General Offices and Factory: Northwestern Terminal,
Minneapolis, Minn.



USAirCo Blowers

Heavy and light duty blowers, single or double inlet, in sizes and capacities for any heating, cooling, ventilating and air conditioning application.

USAirCo Air Washers

Single, double or triple stage 2,500 to 100,000 cfm for cleansing, cooling by cold water or refrigerant, humidifying or dehumidifying.

USAirCo Heating Units

Suspended types with Deflecto diffusing grilles. Floor or wall type blower heaters. Sizes and types for every heating need.

USAirCo Cooling or Heating Cores

Five standard series for central station heating or cooling applications.

USAirCo Cooling Units

Suspended type for cold water or direct expansion applications.

USAirCo Blower Filters

Complete assemblies for warm-air furnace applications.

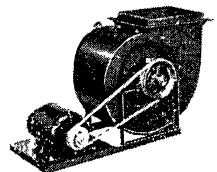
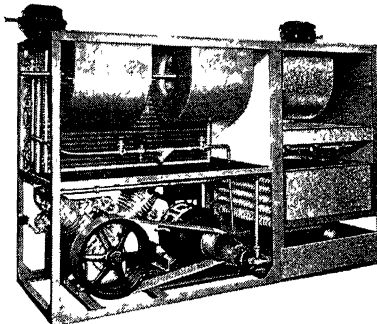
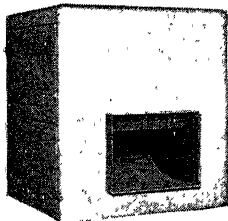
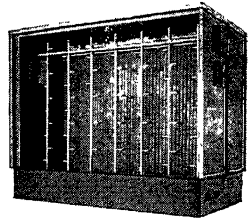
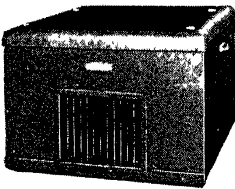
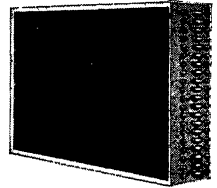
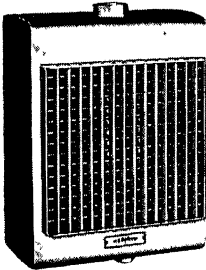
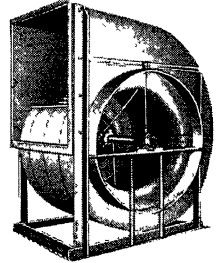
Kooler-aire Package Units

Complete self-contained units for refrigerative, cold water and evaporative cooling. Also room coolers and humidifiers.

USAirCo Deflecto Grilles

Patented diffusing grilles for controlled directional distribution of air.

Write for Latest USAirCo Catalog



Westinghouse Electric & Manufacturing Co.



653 Page Blvd., Springfield, Mass.

Sales, engineering and service available through
Authorized Engineering Contractors in all principal cities

Matched Equipment for Process Air Conditioning and Industrial Refrigeration Applications

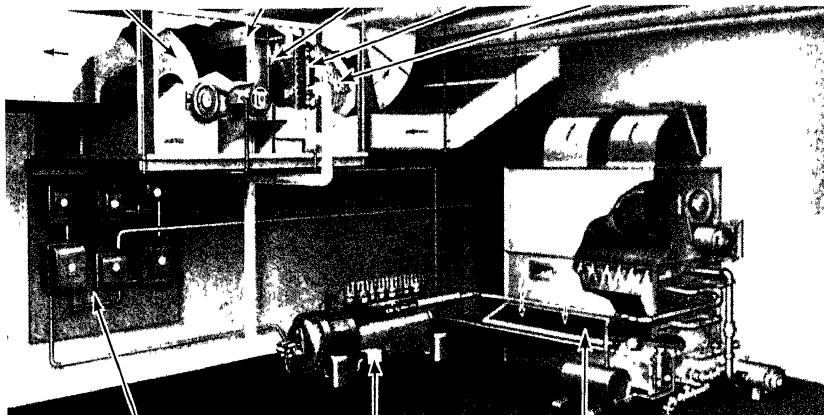
*Air Conditioning
Units*

*Heating
Surfaces*

Humidifiers

*Cooling
Surfaces*

Filters



Electrical Equipment

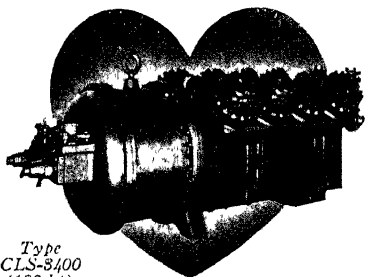
Compressors

Evaporative Condensers

Each essential Westinghouse unit is designed and specified to operate most efficiently with all other units in the system.

The result is the MATCHED system, expertly engineered and co-ordinated to fit the exact requirements.

THE BASICALLY DIFFERENT WESTINGHOUSE HERMETICALLY-SEALED COMPRESSOR

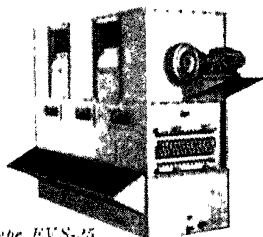


*Type
CLS-3400
(100 hp)
Sizes from 2½ hp to 100 hp*

The HEART of every Westinghouse Air Conditioning and Industrial Refrigeration System is the famous Westinghouse Hermetically-sealed Compressor. This basically different principle has been user-proved over a period of 12 years by more than 2,000,000 Hermetically-sealed units in service. It results in important advantages, including Less Weight, Less Space, Less Maintenance, Lower Operating Costs, Greater Efficiency, Less Wear, Longer Life.

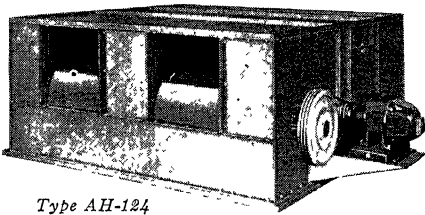
THE AQUAMISER is a self-contained evaporative type condenser which combines the best features of a water-cooled condenser, an air-cooled condenser and a cooling tower. Westinghouse Aquamisers are built in eleven sizes, from approximately 5 tons to 100 tons capacity each, net refrigeration effect.

In addition to use as condensers, Aquamisers are used as process liquid coolers. Temperatures to which liquid can be thus cooled depend upon Wet Bulb air temperature, kind of liquid and its entering temperature. The liquid passes through pipe coils; there is no possibility of its contamination.



*Type RVN-25
Aquamiser*

Air Conditioning Units

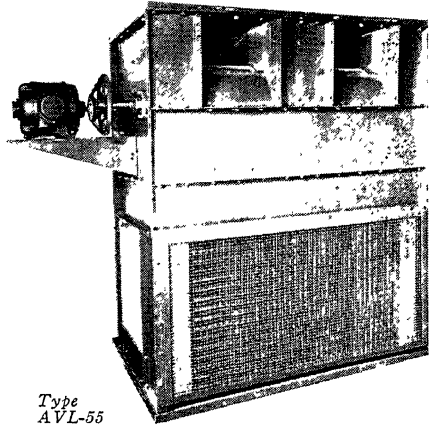


Type AH-124

Westinghouse Types AH (horizontal) and AV (vertical) Air Conditioning Units are factory-built, for installation on central-plant-type air conditioning systems. The compact cabinet contains quiet blower-type fans and provides facilities for installation of cooling and heating coils, filters, and humidifiers. Thus, they eliminate expensive construction work, save space, assure satisfactory performance and low maintenance.

They are available in capacities for Air Conditioning systems of approximately $7\frac{1}{2}$ to 35 tons refrigeration. The fans, included as standard equipment, range in capacity from approximately 1,600 cfm to 12,000 cfm. Thus, either singly or in multiple, practically any system can be satisfactorily served by these units.

Refrigeration Units

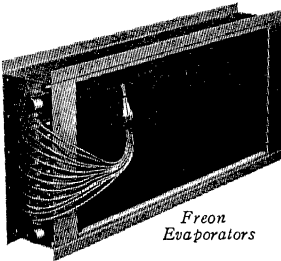


Type AVL-55

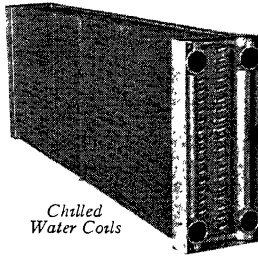
Westinghouse Type AVL Industrial Refrigeration Units are factory built, for installation in product refrigeration rooms. The compact cabinet contains quiet, blower type fans and provides facilities for installation of cooling coils.

Westinghouse Type AVL Units are available in three sizes of approximately $2\frac{1}{2}$ to 15 tons refrigeration. The fans included as standard equipment in the unit range in capacity from approximately 3,000 cfm to 13,000 cfm.

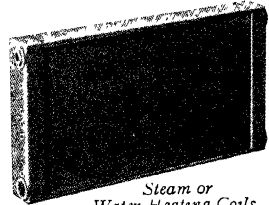
HEAT TRANSFER SURFACES



Freon Evaporators



Chilled Water Coils



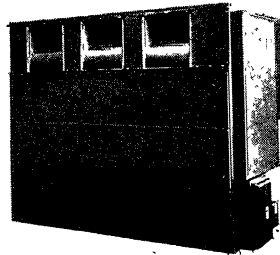
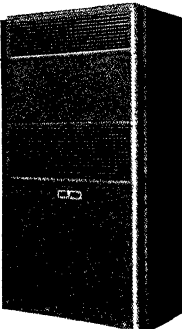
Steam or Water Heating Coils

Coils for Freon, water and steam are available in a wide range of sizes to meet practically any operating conditions.

FACTORY BUILT "PACKAGED" EQUIPMENT

Type LU-850 (25 hp)
Central Plant Type.
Available in sizes $7\frac{1}{2}$, 10, 15, 20 and 25 hp.

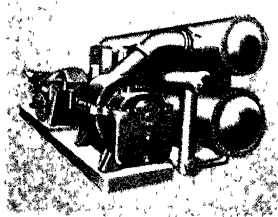
Model SU-50 (5 hp)
Within-the-space Type. Available in sizes 2, 3 and 5 hp.



York Ice Machinery Corporation York, Pennsylvania

Factory Branches and Distributor Engineering
and Sales Offices throughout the World.

Air Conditioning and Refrigeration for maintaining proper atmospheric conditions for industrial processes essential to the war. Installations of unit and central systems in a complete range of capacities and types for every design requirement.

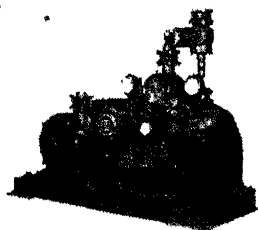


York Turbo Compressor

Condensing and Water Cooling Systems Centrifugal brine and water cooling systems available over wide range of capacities up to 1500 tons refrigeration, steam turbine or motor drive.

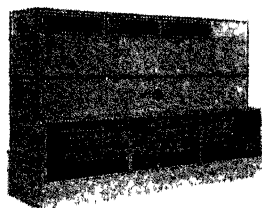
Self-contained dynamically balanced, non-vibrating V/W type reciprocating compressors available in capacities up to 350 tons refrigeration in a single unit, with water cooled or economizer type condensers.

Efficient automatic capacity reduction available for economical operation at reduced load.



York V-W Condensing Unit

The York Economizer A combined forced-draft cooling tower and refrigerant condenser, is available for installations where prohibitive water costs or inadequate drainage facilities preclude the use of a water cooled condenser. Standard factory constructed and built-up units may be used singly or in multiple for applications of any specified capacity. Economizers for use with Freon as the refrigerant are furnished, as standard, with a liquid sub-cooling coil. Economizers also designed for cooling of quench oil and other liquid coolants.

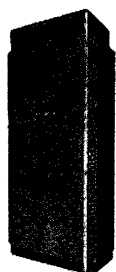


York Sectional Economizer

Air Conditioning Units: A complete line of finned coil, dry coil, wetted surface and spray type sectional air conditioners for horizontal or vertical applications, designed to facilitate installation and the distribution of air. Standard units can be equipped with by-pass feature and arranged for cooling and dehumidifying, heating and humidifying, for year-round processing.

Yorkaire 550 Unit Air Conditioner A compact, self-contained model occupying but 21 x 42 inches of floor space and requiring only water, drain and electrical connections to operate. Special features provide utmost flexibility to meet varying conditions. Temperature dial control provides both automatic and manual temperature control. Air volume and motion may also be adjusted by a special control and the directional grille provides *directed air flow* up, down or from side to side. May be used with ducts if desired.

The Yorkaire 550 is ruggedly built, quiet in operation, equipped with standard fan and compressor motors for AC or DC.



*Yorkaire 550
Unit Air Conditioner*

Dehumidifiers For central station systems where a large volume of air is to be handled and where control of humidity is an essential requirement, the York dehumidifier is especially applicable. Construction features insure a minimum space demand and maximum performance conditions. Standard washers are available in a full range of capacities for industrial installation.

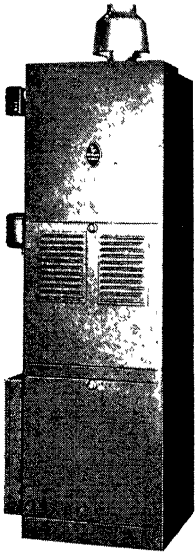


*Let the pup be your
furnaceman and
weatherman too.*

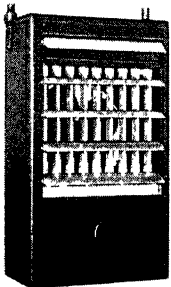
THE BRYANT HEATER COMPANY

17825 St. Clair Avenue - - - Cleveland, Ohio

Engineering, Sales and Installation information on Bryant
Equipment available through Bryant Distributors,
Dealers and Gas Companies in principal cities.



*Vertical
Winter Air
Conditioner*



*Suspended Type
Gas-Fired
Unit Heater*

Bryant Gas designed boilers include tubular cast iron sections, ribbed lower tubes, large steam liberating areas, all heating surfaces readily accessible for cleaning. Insulated metal jacketed covers and Bryant gas controls. Complete range of *AGA* inputs from 45,000 to 3,996,000 Btu/hr for steam and hot water heating systems, volume water heating and industrial process.

Bryant Vertical Winter Air Conditioners complete with blowers, humidifier and filters are compactly designed for small housing, office and industrial use. Bryant tubular cast iron section design and quality controls are standard equipment. Capacities range from 55,000 to 115,000 Btu/hr *AGA* inputs.

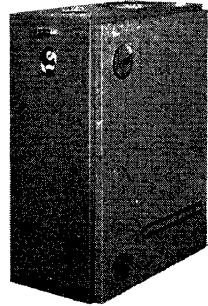
Complete line of forced Warm Air Gas-Fired equipment from 60,000 to 750,000 Btu/hr *AGA* inputs. Efficient cast iron heating sections of vertical tubular construction and large capacity blowers are featured. Humidifiers, filters and Bryant Automatic controls are standard equipment.

Bryant suspended type Gas-Fired Unit Heaters available in five sizes ranging from 65,000 to 255,000 Btu/hr *AGA* inputs. Efficient heat exchange of staggered vertical tube construction. Available in both cast iron combustion chamber, alloy steel tube and all steel types. Quick, clean, efficient heat for all types of industrial and commercial space. Flexible, automatic control and large volume air circulation produce ideal space heating results.

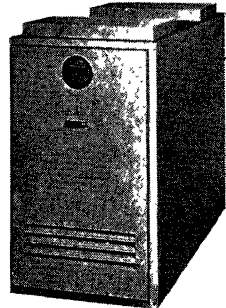
Bryant Dehumidifiers with rotary silica gel bed and completely automatic control find new demands for food dehydration, powder drying, in the manufacturing of airplane

valves, telescopic sights and signal flares—in the testing of airplane engines—and the storage of engine parts, bomb sights and submarine parts. Especially adaptable to industrial requirements and all types of air drying installation.

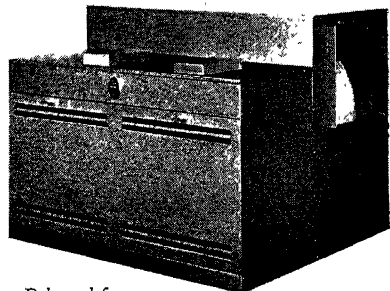
See your local Bryant Distributor or write for complete details and specifications.



*Gas-Fired
Boiler*



*Forced Warm Air
Gas-Fired
Equipment*



Dehumidifier

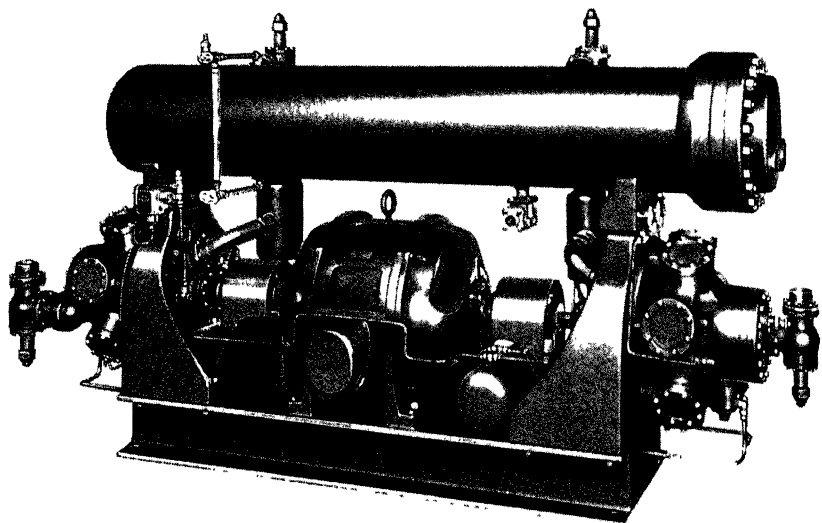
CHRYSLER

AIRTEMP DIVISION OF CHRYSLER



AIRTEMP

CORPORATION, DAYTON, OHIO



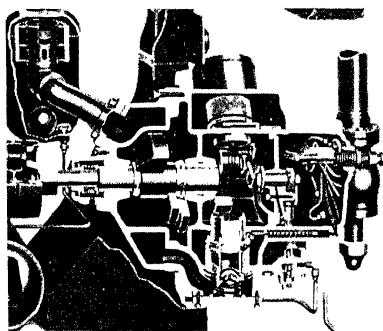
14 CYLINDER MODEL AIRTEMP RADIAL CONDENSING UNITS - Available in 10 to 75 Horsepower Capacities

This heavy-duty radial compressor for use with Freon is especially adapted for refrigeration, for industrial processes or air conditioning. Airtemp radial compressors are directly connected and have force-feed lubrication. The automatic starting unloader and automatic capacity-

reduction unloader give high operating efficiency. Light in weight and economical to operate, these compressors are shipped ready to run. They are especially easy to install since vibration is practically eliminated and no special foundations are necessary.

- AUTOMATIC CAPACITY REGULATION
- UNLOADED STARTING
- DIRECT CONNECTED

- SIMPLIFIED INSTALLATION
- COMPACT DESIGN
- PRACTICALLY NO VIBRATION
- NO SPECIAL FOUNDATIONS NEEDED
- INTERCHANGEABLE PARTS
- LONG LIFE
- ECONOMY



AUTOMATIC UNLOADER

This automatic cylinder unloading device permits starting the compressor under no load and keeps the compressor automatically adjusted to varying loads with no stopping and starting during operation.

CHRYSLER

AIRTEMP DIVISION OF CHRYSLER



AIRTEMP

CORPORATION, DAYTON, OHIO

THE CHRYSLER AIRTEMP AUTO-BALANCE SYSTEM

This system, perfected by Chrysler Airtemp engineers, gives proper indoor humidity and temperature regardless of load or outside weather variations.

PROPER DEHUMIDIFYING TEMPERATURE—is maintained in the active cooling coils because the Chrysler Airtemp Radial Compressor with its automatic cylinder unloader, maintains practically constant refrigerant temperatures under wide load variations.

THUS THE CHRYSLER AIRTEMP AUTO-BALANCE SYSTEM—maintains ideal air conditions at all times under widely varying loads, efficiently and automatically.

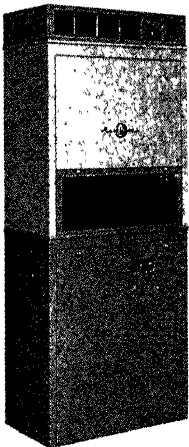
THE CHRYSLER AIRTEMP STAFF—of air-conditioning field engineers, will be glad to show you how this simplest of all air-conditioning systems can aid in solving your problems.

THE CHRYSLER CORPORATION HAS PURCHASED THE CHESTER PATENTS, NO. 1,791,751 AND NO. RE.20,650, IN ORDER TO ASSURE ITS CUSTOMERS OF THE FREE USE OF THE AUTO-BALANCE SYSTEM.

A NEW TOOL FOR INDUSTRY

Accurate production depends not only on skilled workers and modern machines, but on temperature control as well. The Chrysler Airtemp 3 H.P. and 5 H.P. "Packaged" units—with radial compressor hermetically sealed in a bath of oil—are ideal for over 80 per cent of industrial air conditioning requirements.

Standard Airtemp Radial Compressors and Condensing Units are available in 3, 5, 7, 10, 12, and 14-cylinder designs—from 10 to 75 H.P. Airtemp also manufactures Boilers, Furnaces, Oil Burners, and Commercial Refrigeration Units.

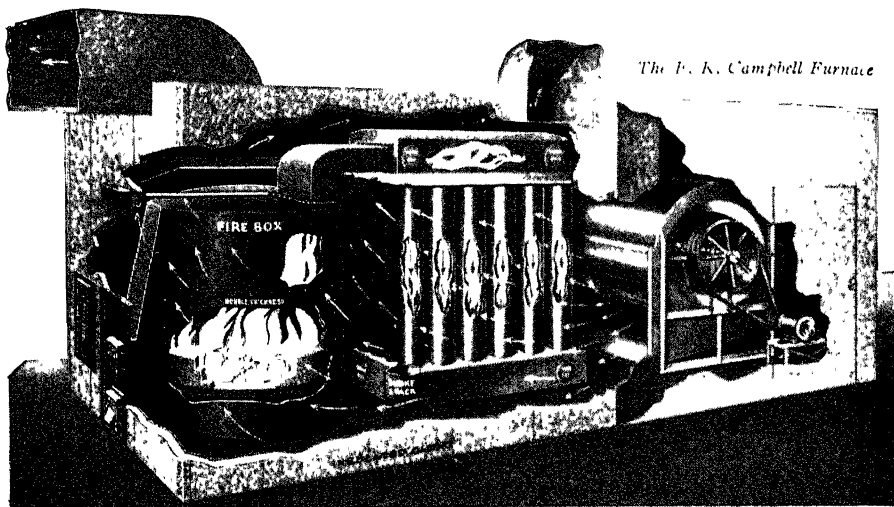


E. K. Campbell Heating Co.

Kansas City, Mo.

MANUFACTURERS - ENGINEERS

FURNACE-FAN SYSTEMS--THERMIDAIRE EQUIPMENT
"EKCCO" BLOWERS



The E. K. Campbell Furnace

FOR: *Industrials—Schools—Churches—Municipal Buildings
Theatres—Hangars—Auditoriums etc.*

Developed exclusively for heavy-duty use, the E. K. CAMPBELL FURNACE-FAN SYSTEM represents 33 years of engineering design and field experience. Standard single units burning any type fuel range from 300,000 Btu per hour to 5,000,000 Btu per hr., with special units available on request for larger loads or processing work. Small units in residential sizes are not available.

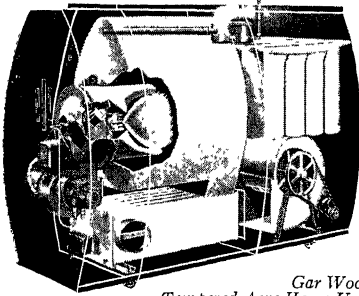
Design features which contribute to the remarkable performance records established include—counter-flow heat transfer—plunge draft—heavy all welded steel construction of locomotive firebox plate and "Toncan" alloy—large combustion space for complete burning of fuel—variable ratio of Btu to cfm available depending on individual requirements of heat loss and cubic space involved rather than on a predetermined inflexible ratio—maximum heat transfer rating of 3,500 Btu per sq ft of heating surface and ratios of heating surface to grate area between 30 to 1 and 50 to 1 as recommended in Heavy Duty Fan-Furnace Section of GUIDE—other general conservative design features based on experience, aimed at trouble free operation, long life, and low operating cost.

Many hundreds of outstanding installations in operation in churches, theatres, schools, municipal buildings, auditoriums, industrials, hangars, etc. Extreme flexibility of equipment, conservative design and individual engineering of jobs, have produced installations whose operating characteristics are superior results, low operating cost, minimum maintenance, and long life. Inquiries on special heating problems and on standard steam or warm air equipment will receive prompt attention.

Like all leading metal products that are American, our equipment has gone to war, and will not be available for the duration except for urgent defense work and direct war use. Inquiries for providing post-war planning are welcome.

Gar Wood Industries, Inc.

7924 Riopelle Street
Detroit, Michigan



*Gar Wood
Tempered-Aire Home Unit*

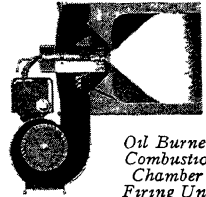
TEMPERED-AIRE UNIT

A high efficiency, direct fired heating unit incorporating a large-volume firebox, an integral economizer, a coordinated oil burner combustion chamber firing unit, a flash-type humidifier, washable cloth filters, and a low speed, resilient-mounted blower.

The primary transfer of heat occurs in the large firebox, having its outlet at the bottom, through which the hot gases pass down into the economizer. Here the gases divide into long thin slices, within the economizer tubes. Each tube is swept at high velocity by cold return air from the blower. The rapidly flowing cool air

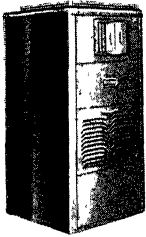
absorbs a maximum of heat from the economizer surfaces.

The burner and fire bowl combustion chamber are built together as an actual unit, with the back end of the fire bowl forming a windbox containing air for combustion at sufficient pressure to offset the effect of draft variations. Air from the windbox passes through metering chutes, set at an angle to cause rotation. Both air and oil rotate and intermingle in a conical spray, resulting in a definitely controlled flame entirely contained within the fire bowl.



*Oil Burner
Combustion
Chamber
Firing Unit*

GAS-FIRED HEATING UNIT

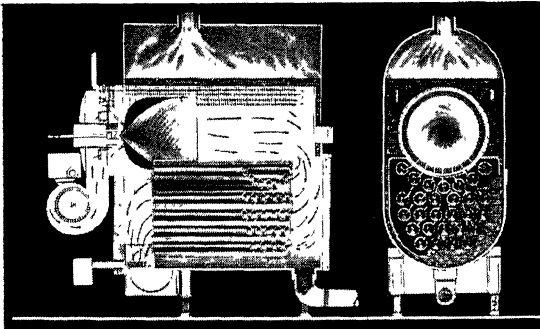


*Gas-Fired
Vertical
Unit*

High efficiency heat exchanger sections are used singly, and in multiple to produce various size units. The horizontal types are ideal for basements with low ceilings. The vertical types occupy small floor space, and are particularly suitable for installation in heater utility rooms located on the first floor, where space is limited.

The horizontal units feature the Gar Wood washable cloth filters for economy and collection of fine dust. An exclusive built-in diverter protects against varying and erratic drafts. The humidifier provides adequate humidity. Canvas couplings for the air bonnets prevent sound telegraphing to the duct work. The large sized slow speed, ball bearing, resilient-mounted and canvas connected blower is driven by a hinge mounted motor with an adjustable speed pulley and built-in overload protection. These features assure adequate delivery of warm air throughout the house, and silent operation.

OIL-FIRED BOILER-BURNER UNIT



An internally fired, downdraft, high efficiency Boiler-Burner unit employing the same firing unit used in the Tempered-Aire Furnace-Burner Unit.

Made in two types, an obround design having a steam chest for steam systems and a cylindrical design for hot water systems. The steam type is available with a built-in tankless water heater. The hot water type can be supplied with a domestic water storage tank having an integral water heater all contained within the boiler jacket.

ST. LOUIS
MEMPHIS
OMAHA
SALT LAKE CITY
CHICAGO

L. J. Mueller Furnace Co.

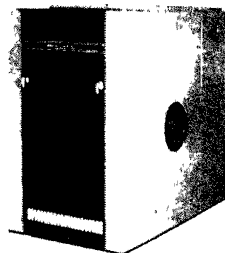
ESTABLISHED 1857

2009 W. Oklahoma Ave., Milwaukee, Wis.

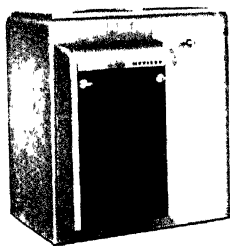
LOS ANGELES
KANSAS CITY
BALTIMORE
PHILADELPHIA
WASHINGTON

SERIES 50 OIL-FIRED WINTER AIR CONDITIONING UNIT

Designed and constructed to meet the needs and purse of the moderate-sized home, this unit automatically heats, filters, humidifies and circulates the air within the home - efficiently and economically. The heating drum and radiator are made of heavy gauge steel, all electric welded, with no joints. Uniform distribution of the conditioned air is secured by the quiet, efficient Mueller fan. Filters furnished are of ample area, and with large dirt-holding capacity. Series 50 unit is available with a Mueller Vaporizing or Pressure Atomizing type oil burner. If desired, any standard burner may be used. Three sizes, from 100,000 to 225,000 Btu per hour.



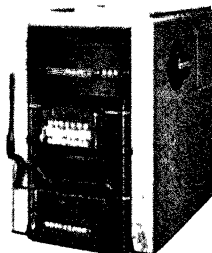
SERIES "EPS" GAS-FIRED WINTER AIR CONDITIONING UNIT



Designed and styled for the modern home, this Mueller unit meets every requirement for an automatic Winter air conditioning unit. Provides balanced distribution of filtered, humidified warm air in ample volume to every room. Heating unit consists of Mueller steel Heatspreader sections, providing quick heat in desired volume. The fan operates quietly and efficiently, with ample capacity for any requirement. Filters thoroughly clean the air. Humidity is supplied automatically. Available in three sizes with AGA input ratings from 90,000 to 180,000 Btu per hour.

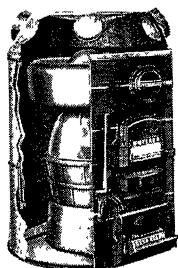
SERIES "FB" COAL-FIRED WINTER AIR CONDITIONING UNIT

The smart, new, straight-line styling and unified design of this unit provides the same smartness, compactness and trim lines usually identified only with automatic heating equipment. The heating unit is of all-cast-iron construction, assuring a lifetime of dependable, economical heat. The heating unit, blower, and filters are enclosed within the crinkle-lacquered, insulated housing. Filters are replaceable type, and are of ample area. The blower provides uniform distribution of the conditioned air to all rooms. Available in six sizes, with hand-fired ratings from 68,000 to 199,000 Btu at register.

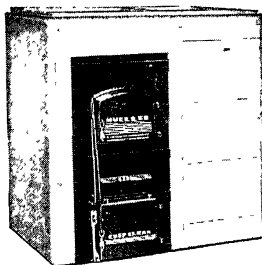


Mueller Heaters For All Fuels

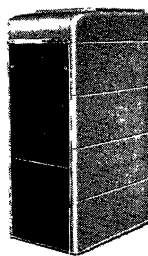
A Complete Line for All Purposes



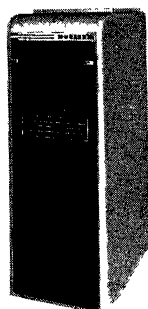
Return Flue all-cast Furnace. 18 in. to 30 in. fire-pots, single and double fire-door styles. Available in round, galvanized or square, lacquered casings.



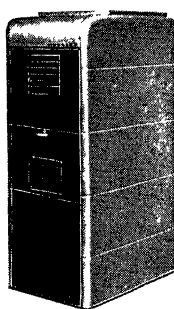
Series P-400 Steel coal-fired fan-filter-furnace unit. Also available with round casing for gravity operation. Four sizes, 20 in. to 27 in. drums.



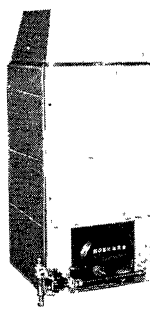
Series OVP oil-fired winter air conditioner—steel construction. Equipped with Mueller vaporizing burner. One size, 80,000 Btu at bonnet.



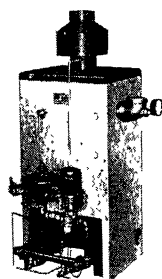
Series CVP gas-fired winter air conditioner. All-cast-iron heating unit. A.G.A. input ratings from 125,000 to 200,000 Btu per hour.



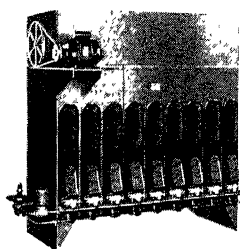
Gas-fired air conditioning furnace. A.G.A. input ratings from 60,000 to 100,000 Btu per hour. Wide range of air deliveries.



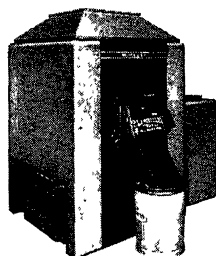
Series G gas-fired gravity furnace. A.G.A. input rating, 90,000 Btu per hour. Available with square or round casing.



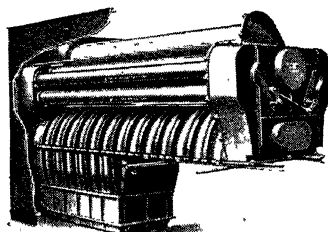
Series "AE" Gas Boiler. AGA ratings, 180 to 1,260 sq ft steam; 290 to 2,015 sq ft hot water.



Gas-fired unit heater. Sizes from 4 to 48 sections. A.G.A. input ratings, 180,000 to 2,160,000 Btu per hour.



Series "SA" stoker-fired furnace, with fan-filter unit. Any stoker may be used. Capacities, 110,000 and 175,000 Btu.



Horizontal Tubular Heaters, for schools, churches and other large buildings. Three sizes, with capacity range from 1,188,000 to 1,390,000 Btu per hour.

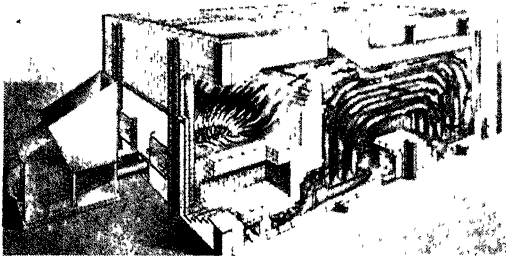
Complete catalogs on each of above units available upon request.

Lee Engineering Company

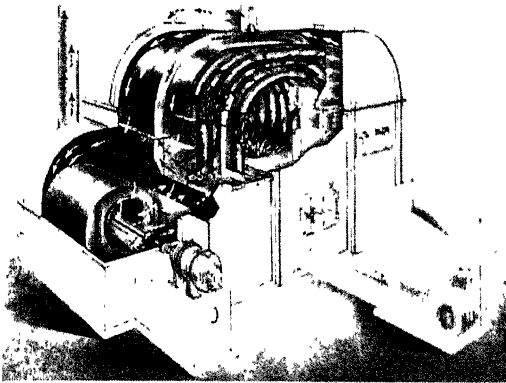
Union National Bank Bldg., Youngstown, Ohio

LEE DIRECT WARM AIR HEATING

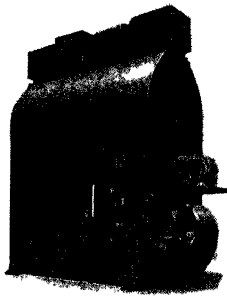
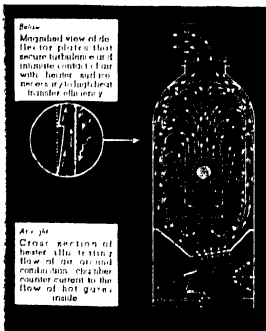
The Lee System of warm air heating generally costs less to install than steam or hot water; utilizes fuel with a high degree of efficiency; distributes the heat exactly where needed; responds promptly without lag; requires little or no maintenance; and needs no licensed attendant. Heaters for use with the Lee System are made in the three types illustrated and described briefly below.



Lee Central System—Brick-Set Tubular Heater



Lee Central System—Steel-Encased Tubular Heater



Lee Unit Heater

LEE BRICK-SET CENTRAL SYSTEM

The Lee Brick-Set Heater is generally furnished in sizes of from 3,000,000 to 8,000,000 Btu per hour, for use as a centrally located heater connected by duct work to the space being heated. As can be seen from the cut-away view at the left, the air to be heated passes through the heater tubes counter-current to the hot gases surrounding the tubes.

LEE STEEL-ENCASED HEATER

The operation of this heater is similar to that of the Brick-Set Heater shown above. This type of heater is usually furnished in sizes of from 1,500,000 to 6,000,000 Btu per hour.

LEE UNIT HEATER

The Lee Unit Heater differs from Lee Central System Heaters in that the Unit Heater is made in relatively small, standardized, self-contained, steel-encased models of up to 1,500,000 Btu per hour capacity for operation either as a unit heater without connecting ducts; or as a central heater with ducts.

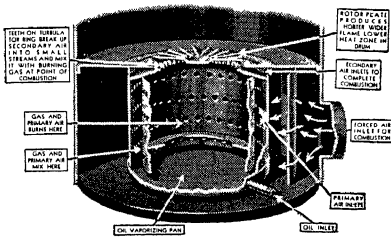
All three systems can be operated with any type of fuel.

For further information write for catalog.

The Quincy Stove Manufacturing Co.

Quincy, Illinois—U. S. A.

MONOGRAM Automatic Oil Burning Furnaces



MONOGRAM Turbulent-Flame Vaporizing Oil Burner

An important factor in the high efficiency of all MONOGRAM Heating Equipment is the MONOGRAM Turbulent-Flame Vaporizing Oil Burner—a new method of oil burning. No moving parts, nor frequent cleaning or servicing. Products of combustion are confined to the heating drum, and oil vapors, gas, or products of combustion can not escape into the building. The burner is continuously in operation—either

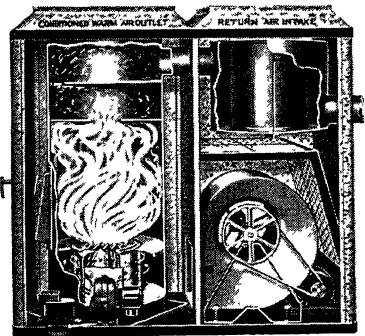
on low or high flame, and maintains sufficient burner temperature to completely vaporize oil so that combustion occurs immediately when oil enters the burner—quick, efficient.

The cycle of operation from low fire to high fire and again reducing to low fire is gradual and without puff or explosion. In case of electric power failure the burner operates on low fire without danger of flooding, and can be operated manually by adjusting the oil flow and the draft regulator as required. Burner approved by the Underwriters' Laboratories, Inc.

Ten Furnace Models

Three sizes of Booster Gravity Units for quick and inexpensive change from coal to automatic oil heating, equipped with limit control, mechanical draft, and thermostat—these three models may be equipped with blowers for Full-Forced Circulation. Three sizes of Full-Forced Winter Air Conditioning units complete with air filters, automatic humidifiers, blowers, economizers, mechanical draft, limit control, blower switch and thermostat. An upright Full-Forced Winter Air Conditioner for basement or utility room installation equipped with separate blower for draft and air, limit control, blower switch and thermostat. Heating drum 12 to 14 gauge—all cabinets insulated with one inch fibreglas. Mechanical draft only on high fire. Low fire operates on .02 inch draft.

Special oil service station models from 50,000 to 72,000 Btu at bonnet—efficiency obtainable 80 to 81.7 per cent cfm 550 to 850.



Specifications for MONOGRAM Oilfire Furnaces

Type of Furnace	Booster Gravity			Full-Forced Warm Air			Full-Forced Winter Air Conditioner			Upright
Model No.	75	100	200	76	103	203	125	150	250	102
Btu Rating at Bonnet	75,000	90,000	125,000	75,000	90,000	125,000	90,000	120,000	150,000	75,000
Per Cent Efficiency Obtainable	80	82	82	80	82	82	84	84	84	80
Air Delivery—cfm				400-700	800-1400	1000-1600	800-1400	800-1400	1000-1600	800-1400
Cabinet Floor Size—In.	26 1/4 x 26 1/4	30 x 30	36 x 36	26 1/4 x 52 1/4	30 x 56	36 x 66	26 1/4 x 49 1/2	30 x 56 1/2	36 x 68 1/2	27 x 27
Cabinet Height—In.	50 1/4	60	60	50 1/4	60	60	50 1/4	60	60	71
Height With Bonnet	64 1/2	74 1/4	74 1/4							
Max Gal. Oil per Hr.	0.69	0.81	1.12	0.69	0.81	1.12	0.80	1.05	1.32	.69
Min Gal. Oil per 24 Hr.	1.50	1.00	1.50	1.50	1.00	1.50	1.50	1.00	1.50	1.50

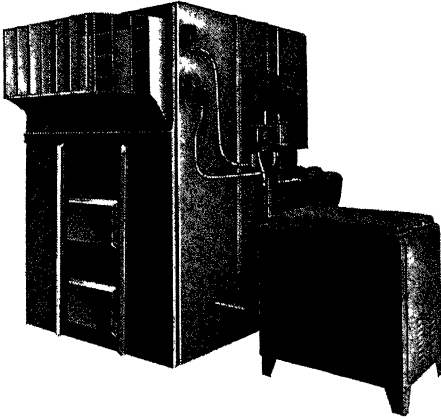
New MONOGRAM Patented Burner vaporizes oil quicker—more completely, then induces both primary and secondary air in proper relation to oil, producing the highest known operating efficiency. Double baffle heat unit made possible by shorter, wider flame, stops rush of heat out the flue, creates a lower heating zone which combined with the clean, perfect combustion produces unheard of operating efficiencies.

Airtherm Manufacturing Company

710 S. Spring Ave., St. Louis, Mo.

THE ENGINEERED LINE OF UNIT HEATERS

DIRECTHERM WARM AIR HEATERS FOR OIL, GAS OR COAL are available in six standard sizes with capacity from 300,000 to 1,500,000 Btu. They are made of heavy gage steel plate, with major sections all welded and flue gas headers are readily cleanable.



VENTILATION AND AIR RE-CIRCULATION. The Directtherm can be easily hooked up for outside air intake. Air filters may be used in the intake box when desired.

INSTALLATION. These units, when assembled, require nothing more than a stack and an electrical connection (plus a gas or oil fuel hook-up) and can be made fully automatic in operation when using oil, gas or stoker.

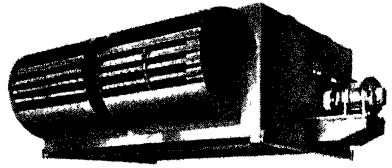
PORTABILITY. Directtherm Heaters may be readily removed from one location to another or from one plant to another.

DUCT WORK. While the Directtherm Heater will provide thorough heat distribution without duct work, where necessity requires it may be hooked up with a system for further heat distribution. The fan equipment is of ample capacity to overcome duct resistances.

ENGINEERING SERVICE

The Airtherm Mfg. Co. Engineering Department and District Representatives are at all times available for consultation. At your request we will place experienced engineering aid at your disposal. *Representatives in all principal cities.*

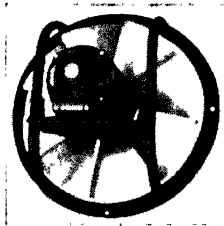
AIRTHERM LINE OF UNIT HEATERS represent a full range of capacities in all types.



THE AIRBLANKET. A revolutionary type of heating unit which holds the heat in the working zone through the use of the over-riding cold air blanket. This unit is available either in the centrifugal fan type as illustrated above or in the propeller fan type. They are designed for wall or ceiling mounting and are especially recommended for high ceiling jobs. Bulletin No. 210 contains complete details of the Airblanket method of heating.

THE AIRVECTOR. A highly efficient, large capacity, centrifugal fan heater for all types of installations, available for floor wall or ceiling mounting.

THE AIRVECTOR. A newly re-designed propeller fan type unit heater backed by 30 years of manufacturing experience. The Airvector is available for ceiling suspension or mounting from the floor on a recirculating stack.



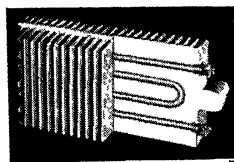
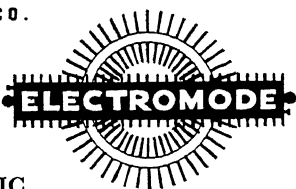
AIRTHERM EXHAUST FANS have been expressly designed to meet industrial and general requirements for rugged, heavy duty type fan of simplified construction that would minimize both installation and maintenance problems. Capacity charts and literature will be forwarded immediately on request.

ELECTRIC AIR HEATER CO.

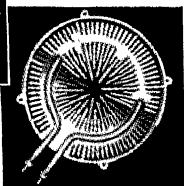
DIVISION OF AMERICAN FOUNDRY EQUIPMENT CO.

MISHAWAKA, INDIANA

Manufacturers of

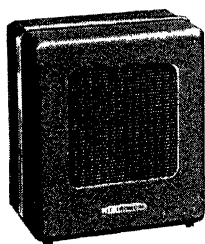


*Cross-section Views of
Electromode Heater
Grids—Circular and
Rectangular Types*



ALL- ELECTRIC AIR HEATERS

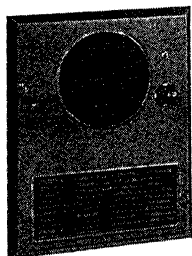
Cast aluminum grids in electric heaters are a radically different innovation from the popular conception of electric heating units. Aluminum, a metal of highest thermal conductivity, is cast on a tubular element. This process seals the heating element, preventing all oxidation.



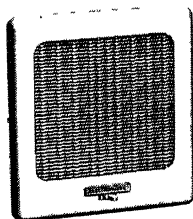
HOME & OFFICE HEATERS

Model PJ-15—A package of comfort for chilly bathrooms, nursery, den, office, workshop, etc. Can be used in average baseboard receptacle on 115 volts.

The Bilt-in-Wall Model—At left, features our exclusive cast aluminum element and down-draft warm air delivery. Capacities: 1 KW to 5 KW (3415 Btu to 17,075 Btu). Designed for 2 in. x 4 in. wall construction. Also available in Portable Models.

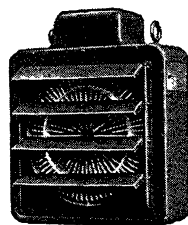


Model WJ-15 Bilt-In-Wall Electromode—Rated 1500 watts, 115 volt, 60 cycle, 1 phase (5123 Btu per hour). Ideal for bathrooms or auxiliary heating anywhere. Designed for standard 2 in. x 4 in. wall construction—approximate wall opening required: 10 1/4 in. wide x 11 3/4 in. high.

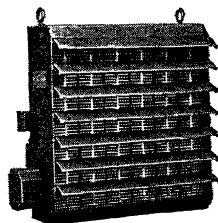


INDUSTRIAL HEATERS

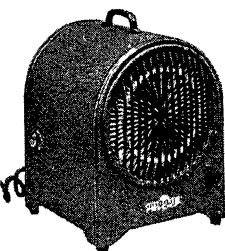
Circular Grid—Made in capacities from 2 KW (6830 Btu) to 9 KW (30,735 Btu). Each heater is provided with eye bolts and adjustable louvers. The cabinets are made of heavy furniture steel.



Industrial Unit—Made in capacities from 10 KW (34,150 Btu) to 90 KW (307,350 Btu). The cabinet is made of heavy steel and furnished with eye bolts and adjustable louvers.



Industrial Portable—A heavy duty portable Electromode made in capacities from 1 KW (3415 Btu) to 9 KW (30,735 Btu). Each heater is a self-contained unit complete with cable and with a suitable plug cap.



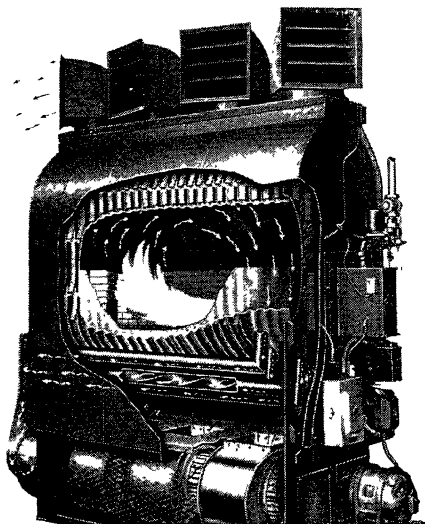
Send to the factory for literature and complete details on any or all Electromode models. Our Engineers will be glad to estimate heater sizes for your application and submit full recommendations. Qualified engineering representatives are located in the principal cities for prompt service. A wide variety of models and capacities are available for any kind of a space heating job.

DRAVO CORPORATION

HEATER DEPARTMENT

300 Penn Avenue, PITTSBURGH, PA.

Sales Offices in Principal Cities



Cut away view showing combustion chamber principles as applied to gas, oil, or combination gas and oil burning units. Note corrugated combustion chamber with fins and deflectors welded thereto for maximum heat transfer efficiency. Economizer tubes utilize part of the heat of the flue gases. Heated air is discharged at top, return air taken in at floor level, a practice that concentrates heated air at working levels.

Savings of scarce metals, fuel, cost of maintenance and cost of labor in operation are factors influencing favorable acceptance of Dravo Heaters.

War conditions demand speed of installation and curtailment in the use of critical materials. Dravo Heaters are shipped with refractory and firewall in place, are installed by simply connecting to fuel and power supply, and their construction represents a saving in critical metals of 30 to 40 per cent over conventional steam plants with distributing systems.

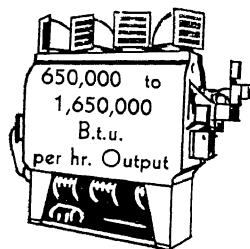
Each heater is a self-contained unit, operated individually. A heating system for any size structure may be formed with a combination of one or more heaters. Dravo Direct-Fired Heating Systems save man-hours, money, transportation—all essential to the war effort.

Dravo Direct-Fired Heaters are used for permanent installation and also often used to supply temporary heat in new construction or plant expansion.

The exceptionally high heat transfer efficiency is the result of two fundamental design features—first, accurately controlled combustion of fuel and air, and second, highly effective transfer of heat to air. Standard stock sizes are obtainable for production of 650,000 to 4,000,000 Btu output per hour. Dravo Bulletin No. 505 with detailed description mailed on request.

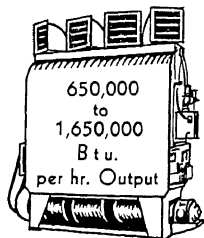
Specification Data Sheets for any type or capacity are furnished on request.

GAS-OIL COMBINATION . . . Floor Set . . . Top Discharge . . . Rear Fired . . . Standard V-Belt Drive—This series of heaters is equipped to burn either Heavy or Light oil with alternate gas burner. Equipment consists of a complete, separate



burner for each fuel, each burner having a complete set of controls. The controls and wiring are so arranged that either burner can be put into operation by simply throwing a switch.

GAS . . . Floor Set . . . Top Discharge . . . Rear Fired . . . Standard V-Belt Drive—This series as well as all others is designed to deliver the maximum output per square foot of floor space occupied. Because of their unique design they fit into the heated space and are dependable and efficient. They readily lend themselves to a wide variety of applications, using either natural or manufactured gas.



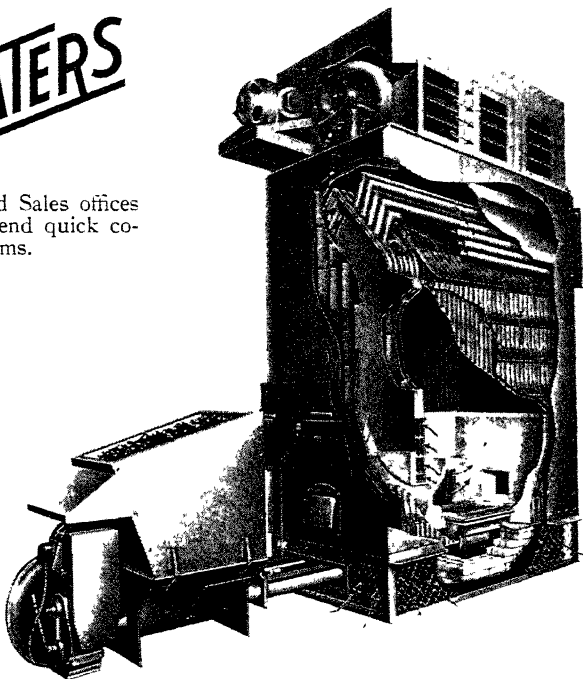
DRAVO DIRECT FIRED HEATERS

There are 47 Branch and Sales offices strategically located to extend quick co-operation on heating problems.

Right. Hopper fed model, capacities 1,000,000 to 4,000,000 Btu output per hour. Also available for bin-feed, Anthracite or Bituminous coal.

COAL FIRED SERIES

—the Dravo coal-fired, self-contained Heater is particularly adaptable in areas where coal is the cheapest or easiest fuel to obtain. Coal fired heaters may be converted to either gas or oil firing should conditions change. The entire series of Dravo Direct-Fired Heaters has the utmost flexibility. Enough applications, combinations, and adaptations are available to meet any set of reasonable conditions. The same unique principle of corrugated welded combustion chamber, with its multiplicity of welded fins and deflectors, is employed. The entire series has the DRAVO non-clinking air-cooled setting incorporated in the design. Available for either bituminous or anthracite coal; equipped with either hopper feed or



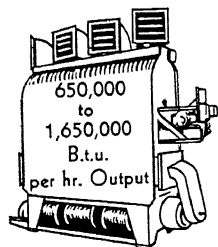
bin-feed stoker, installed under either end of the heater. Capacities: 1,000,000 to 4,000,000 Btu per hour output.

There are two models of Dravo Direct-Fired Coal Heaters specially designed for large unit applications which can be used as central heating plants. Overhead or underground duct systems may be installed when necessary. These large models are available in ratings from 4½ to 8 million Btu output per hour.

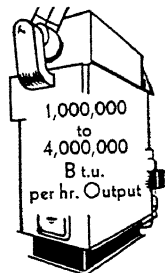
Specification Data Sheets for any type or capacity are furnished on request.

OIL, Floor Set, Top Discharge, Front Fired Standard V-Belt Drive—This series obtainable in light oil or heavy oil fired models in all Dravo Direct-Fired

Heaters. Economy of fuel consumption is the result of careful over-all designing and constant improvement over many years. In summer they may be used for air circulation.

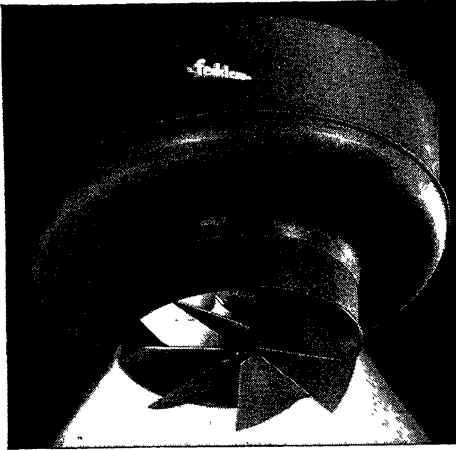


COAL . . . Hand Fired Model—Available for bituminous coal or coke. Equipped with full set of rocking and dumping grates, supporting frame and lugs; undergrate blower assembly; shaker bar and handle; lower ashpit front; door and frame. Available in ratings of 1,000,000 to 4,000,000 Btu per hour output capacity. Convertible at any time to bin or stoker feed, gas or oil consumption.

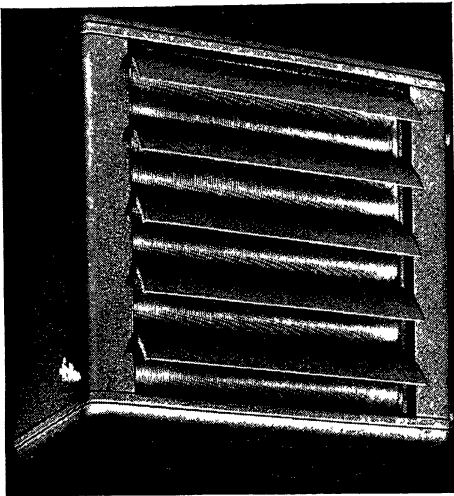


FEDDERS

MANUFACTURING COMPANY, INC.
85 TONAWANDA ST.
BUFFALO, NEW YORK



Series 8 Unit Heaters—150 to 1800 EDR



FEDDERS UNIT HEATERS Horizontal Type

Provide directional control of heated air. Maximum heat transfer per pound of metal—75 to 1200 EDR.

FEDDERS UNIT HEATERS Vertical Type

Designed for high ceiling installations where supply and return piping will not interfere with overhead equipment such as craneways, shafting, tall machinery. High velocity fan delivers heated air down to the working zone where draftless diffusion is accomplished by using suitable directional outlet to fit conditions.

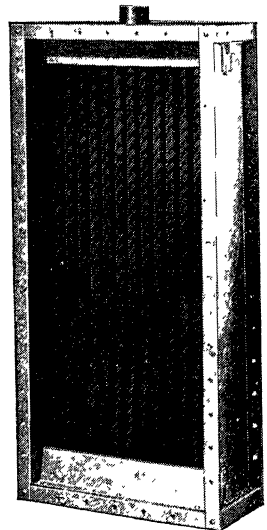
FEDDERS TYPE K HEATING COILS

Strong, rigid casings . . . large cylindrical headers . . . full-floating protection against overall expansion . . . top header tri-point supported by center anchorage brackets and drop forged bronze trunnions . . . knee action relief of differential expansion among tubes . . . scale breaker-tube orifices . . . floating type tube supports . . . permanently bonded fins and tubes.

7 Standard Face Widths $12\frac{3}{4}$ in. to $36\frac{1}{8}$ in.

18 Standard Face Lengths $1\frac{1}{2}$ ft. to 10 ft.

*Also
Unit Coolers
Cooling Coils
Air Conditioning
Units*



Hastings Air Conditioning Co., Inc.

Hastings, Nebr.

Manufacturers of



Air Conditioners.
Unit Heaters.
Utility and Package Blowers.

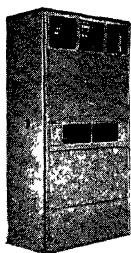
Dealers and Representatives in Principal Cities

A Complete Line of Highly Successful COLD WATER Air Conditioners.
Capacities listed depend on entering air and water temperatures.

All equipment available for combination heating and cooling.

FLOOR MODELS

Floormasters—Unusual design and special features permit maximum installation possibilities with minimum floor space and installation costs.



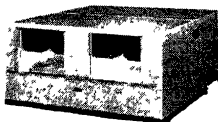
Air Delivery—2240 cfm.
Cooling Capacity—3 to 6 tons. Dimensions—Height 93 in., Width 48 in. Depth 25 in. Motor— $\frac{1}{2}$ hp. Filters—3 16 in. x 25 in.

Royal—For offices, homes, hospitals, etc.

Air Delivery—590 cfm.
Cooling Capacity—1 to 2 tons. Motor— $\frac{1}{6}$ hp. Filter—1 16 in. x 25 in.

Dimensions—Height 40 in., Width 28 in., Depth 20 $\frac{1}{2}$ in.

CENTRAL PLANTS



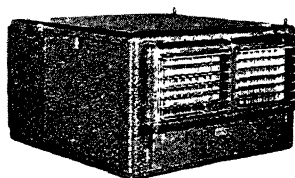
Sectional construction for ease of handling. Motors inside mounted to provide very neat appearing compact units.

SPECIFICATIONS

Size	CFM	Motor Hp	Filters	Capacity Tons
CP 30	3,000	1	5	4-9
CP 40	4,000	1	8	6-12
CP 60	6,000	2	10	9-18
CP 80	8,000	3	12	12-24
CP120	12,000	5	20	18-36

GENERAL UTILITY MODELS

Master—Singly or in multiple are suitable for any business or space size. Large jobs handled without duct work by proper location of units.



Air Delivery—2,240 cfm. Cooling Capacity—3 to 6 tons. Dimensions—Height 29 in., Width 49 in., Depth 50 in. Motor— $\frac{1}{2}$ hp. Filters—4 16 in. x 23 in.

Majestic—Similar to Master except size. Air Delivery—1120 cfm. Cooling Capacity—1 $\frac{1}{2}$ to 3 tons. Motor— $\frac{1}{4}$ hp. Filters—2 16 in. x 25 in. Dimensions—Height 26 in., Width 28 in., Depth 40 in.

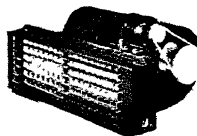
Zephyr—Same capacity, motor and filter as the Royal. For use where suspended or concealed units are desired. Dimensions—Height 26 in., Width 24 in., Depth 28 in.

UNIT HEATERS

Centrifugal Type for extreme quietness and efficiency.

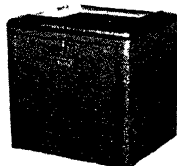
Steam pressure—
to 150 lbs per sq in.

Finish—Brown wrinkle enamel and stainless steel louvers.



PACKAGE AND OPEN TYPE BLOWERS

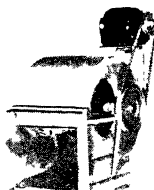
May be knocked down for narrow doorways. Finished in attractive green wrinkle.



Utility type blowers are available with or without motors and in any discharge desired.

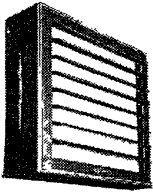
All sizes from 9 in. to twin 21 in.
Air deliveries from 1000 cfm to 16,000 cfm.

Write for Catalogues, Literature, or Information



Kramer Trenton Co.

Manufacturers of
HEATING, COOLING AND REFRIGERATION DEVICES
Trenton, New Jersey



KRAMER UNIT HEATERS

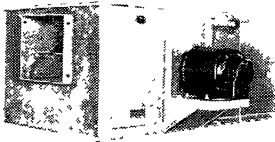
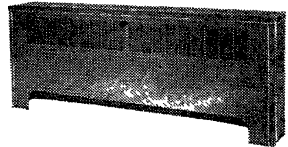
All-copper heating element. Oval-section tubes with hair-pin bends. High discharge air velocity insures proper heat distribution. For pressures up to 150 lb.

Send for Bulletin H-141

KRAMER COPPER CONVECTORS

All-copper heating element. Oval tubes with fins metallically fused to tubes. Noiseless operation. Guaranteed for operating steam pressures up to 50 lb

Send for Bulletin H-240



HEATING and AIR CONDITIONING UNITS for Residential Use

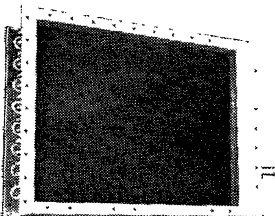
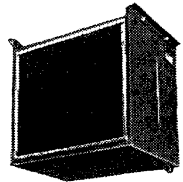
Designed for split-system installations. A range of sizes adaptable to residential requirements. Rubber mountings and flexible connections minimize noise.

Send for Bulletin SS-341

KRAMER COMFORT COOLERS

Suspended type for small tonnages—1 to 3 tons—and for remote compressor operation. All-copper coils. Specially designed grille for proper diffusion.

Send for Bulletin R-142



KRAMER TURBO-FIN

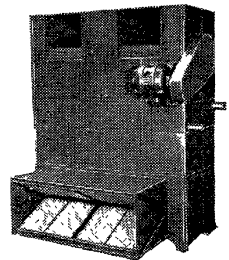
For blast heating and cooling. All-copper blast surfaces; fins metallically fused to tubes. Air side flow-disturbers. Coil finished in electro tin plate for permanence.

Send for Bulletin A C-540

KRAMER AIR CONDITIONING UNITS Ceiling and Floor Type

Wide variety of sizes and capacities—2 to 30 tons in cooling; 65,000 to 1,280,000 Btu per hour in heating. Accurately rated. All-copper Turbo-fin coils; fiber-glas air filters. Complete cabinet types for either floor or ceiling mounting.

Send for Bulletin A C-440



Kramer Trenton Co.

Manufacturers of

HEATING, COOLING AND REFRIGERATION DEVICES

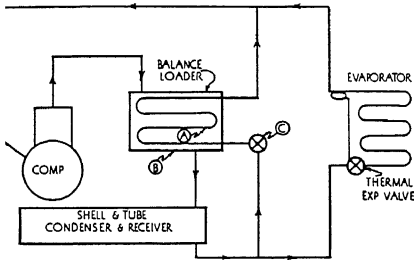
Trenton, New Jersey

HEAT TRANSFER PRODUCTS

BLAST COOLING COILS • BLAST HEATING COILS • AIR CONDITIONING UNITS
COMFORT COOLERS • UNIT HEATERS • COPPER CONVECTORS • FINNED
COILS • BARE TUBE COILS • PLATE COILS • CONDENSERS • HEAT INTER-
CHANGERS • WATER COOLING EVAPORATORS • ICE MAKERS • UNIT
HEATERS;—Coolmaster Panel Type—Floor Type—Freezing Oven—Freezing Shower—
COMBUSTION ENGINE

RADIATORS • OIL COOLERS

KRAMER Balance Loader SYSTEM



The **KRAMER Balance Loader SYSTEM**—(Patented) is a modulating refrigeration system capable of varying from per cent to 100 per cent of full load, and maintaining a fixed minimum back pressure in the suction line and in the compressor crank case. The **KRAMER SYSTEM** will automatically compensate for varying evaporator loads, resulting in an infinite number of compressor capacity points, giving straight line capacity modulation.

The **KRAMER SYSTEM** gives a full range of modulation at a fixed minimum back pressure throughout the entire low side.

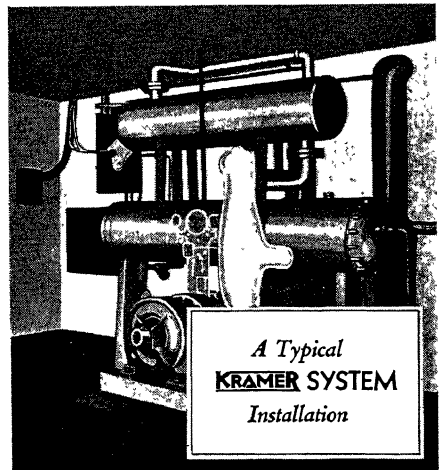
Referring to the diagram—the Balance Loader is fundamentally a heat exchanger consisting of a direct expansion coil (a) within a cylinder shell (b). The expansion coil is controlled by an automatic expansion valve (c) set to operate at a predetermined pressure. The hot gas from the compressor is passed through the shell of the Balance Loader before going to the main condenser.

As the heat load at the evaporator is reduced, the resulting reduction in suction pressure opens the automatic expansion valve at the Balance Loader which will

automatically maintain the suction pressure at a constant predetermined level.

Among the **Advantages** achieved by the use of the **KRAMER SYSTEM** are a constant back pressure in suction line and crank case, elimination of lubricating and seal troubles due to unusually low crank case pressures, prevention of icing of air conditioning coils, partial flooding of the evaporator is made possible, close control is achieved, complicated and excessive control instrumentation is eliminated.

The **KRAMER SYSTEM** can be applied to new or existing refrigeration systems. It can be used in conjunction with air conditioning, industrial cooling, liquid cooling and commercial refrigeration. It is particularly adaptable to systems having wide heat load fluctuations and where precision control is required.



McQuay, Inc.

1602 Broadway, N.E., Minneapolis, Minn.

MANUFACTURERS OF AIR CONDITIONING EQUIPMENT

Sales Offices in all Principal Cities

- Air Conditioners
- Air Conditioning Coils
- Blast Heating Coils
- Refrigeration Coils
- Convection Radiation
- Unit Heaters
- Unit Coolers



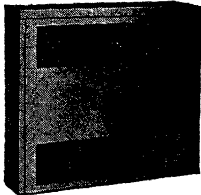
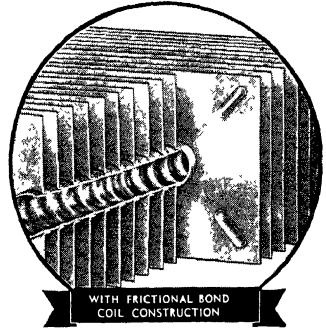
- Comfort Coolers
- Blower Coolers
(Suspended & Floor Type)
- Room Coolers
(Cabinet Type)
- Ice Cube Makers
- Icy-Flo Accumulators
- Zeropak Low Temp. Units

THE EXCLUSIVE McQUAY FRICTIONAL BOND FIN-AND-TUBE COIL ASSEMBLY

The McQuay Fin and Tube assembly in all McQuay coils and cores is one of the reasons McQuay products are considered "Tops in Over-All Efficiency" by many heating and refrigeration authorities.

Heat transfer efficiency primarily depends on three elements in coil construction. First, "Area of Contact," Second, "Contact Pressure" and finally "Quality of Contact" between collar and tube.

In McQuay coils *all three* necessary elements are found developed to their highest degree. The famous McQuay "Wide Fin Collar" plus Exclusive Hydraulic Expansion together with the polished surface, secured by "spinning" the fin collar, truly provides the last word in Heat Transfer.



STANDARD CONVECTOR

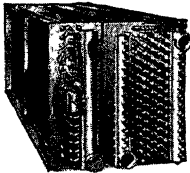
McQUAY STANDARD CONVECTORS

The Standard all purpose Convector has been designed to meet all heating requirements. They are available for free standing, partially recessed, fully recessed and wall mounting applications.

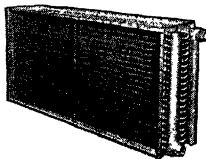
All enclosures are constructed from high grade steel, properly reinforced to make a sturdy cabinet.

The heating element is constructed of a series of round tubes to which are attached die formed radiating fins, which are bonded to the tubes by an exclusive process.

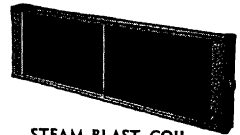
We offer the services of our Engineering and design department to help solve your heating problems.



COMBINATION COOLING COIL



WATER COIL



STEAM BLAST COIL

MORE THAN 1,000,000 STANDARD COIL TYPES AND SIZES

McQuay manufactures the most complete line of Standard Coils in the Industry.

Coils for Heating—1 to 10 rows deep using low or high pressure steam or hot water.

Non-Freeze—(steam distributing tube) type coils 1 and 2 rows deep.

Removable Plug—(cleanable tube) type coils 1 to 12 rows deep.

Water Coils for Cooling—1 to 12 rows deep.

Direct Expansion Coils—for cooling 1 to 10 rows deep.

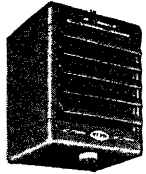
Refrigeration Coils—all types and sizes.

Special Coils—of various materials furnished on order for special applications.

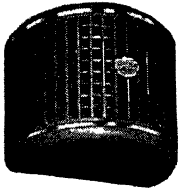
UNIT HEATERS

Critical materials must be conserved. McQuay Unit Heaters having a steel core of highest heat transfer efficiency, now have a sturdy but simple cabinet of non-metallic material. Truly it can be said that McQuay construction provides "greatest Btu per pound of metal used."

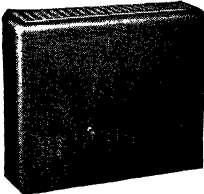
All McQuay Unit Heaters are furnished in a wide range of sizes with motors to meet all electrical current characteristics, making it convenient to select the proper size heater for every installation.



STANDARD UNIT
HEATER



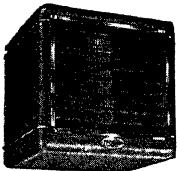
RADIAL UNIT
HEATER



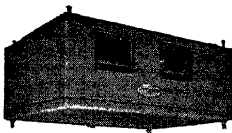
CABINET TYPE UNIT
HEATER



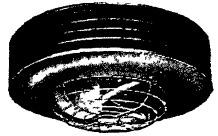
COMFORT COOLER



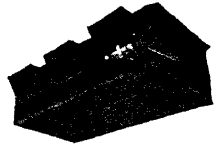
COMFORT COOLER



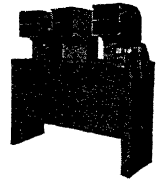
AIR CONDITIONER
(YEAR-ROUND)



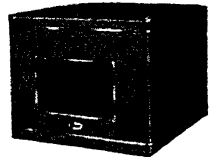
DOWN FLOW UNIT
HEATER



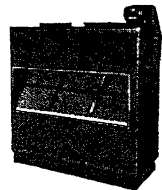
BLOWER TYPE UNIT
HEATER



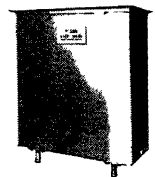
BLOWER TYPE UNIT
HEATER



AIR CONDITIONER



AIR CONDITIONER
(YEAR-ROUND)



ACCUMULATOR

McQUAY COOLERS

For Industrial Application

Made in two types—one for use with water or brine; another for Freon or methyl chloride. Eight sizes in each type—all with 4-speed motors.

AIR CONDITIONERS—COLD WATER AND FREON TYPES

For Industrial Application

Choice of recirculation of indoor air, entire intake of outside air, or a combination of both. Cold water or brine used in one type; Freon or methyl chloride in another. Modern "sound isolated" construction assures quiet operation. Capacities to 6 tons.

CENTRAL SYSTEM AIR CONDITIONING UNITS

Suspended and floor types, cools, dehumidifies, filters, and circulates air in summer, heats, humidifies, filters and circulates air in winter. Extreme flexibility and accessibility "built-in." Cooling capacities from 5 to 50 tons in both Suspended and Floor Type.

McQUAY

ICY-FLO ACCUMULATORS

The new practical "Storage-Battery" for refrigeration effect is now available for handling heavy loads of short duration.

All McQuay Units are available in a large range of sizes, under WPB Order L-107 for Army, Navy, Maritime Commission, Coast Guard and essential industries. Write for Descriptive Bulletins. McQuay, Inc., 1602 Broadway St. N.E., Minneapolis, Minnesota.

Modine Manufacturing Company

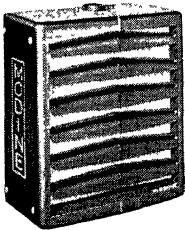
Heating and Air Conditioning Division

General Offices: 17th and Holburn Sts., Racine, Wis.

Factories at Racine, Wis. and La Porte, Ind.

Branches in all Principal Cities

MODINE UNIT HEATERS



Front View



Back View

Horizontal Delivery Models—Differing only in condenser design, these unit heaters are available with either steel or copper condensers, the latter being limited primarily to shipboard application.

Steel Condenser—Heavy cylindrical steel or iron tubes and headers are brazed into integral, pressure-resisting units. Steel fins permanently bonded to tubes with metal. Entire condenser assembly is given protective lead-alloy coating to reduce corrosion hazard. Expansion provided for by floating lower header, heavy tubes and parallel heavy brazing.

Direct - Pipe - Suspension—Modine patented feature permits suspending unit directly from supply line without additional time and labor wasting supports; also permits complete rotation of unit for redirection of air stream.

Bonderized Casing—Casing protected from rust by Parker Bonderizing.

Safety Fan Guard—Staunch, steel safeguard built into unit protects against danger of unshielded fan.

CAPACITIES AND DIMENSIONS (For Steel-Condenser Units)

Model No.	Btu/hr*	Cfm	Rpm	Over-all Height	Width	Depth Less Motor
H-140 S/S	33,600	550	1635	17 3/4"	14 1/4"	9"
H-170 S/S	40,800	600	1530	20 1/8"	14 1/4"	9"
H-250 S/S	60,000	1060	1145	22 1/2"	19"	11"
H-350 S/S	84,000	1510	1120	24"	19"	11"
H-490 S/S	117,600	2300	1110	27 1/2"	23"	11 1/2"
H-580 S/S	139,200	2440	1125	27 1/2"	23"	11 1/2"
H-660 S/S	158,400	2660	1120	29 1/2"	24 1/2"	11 1/2"
H-715 S/S	171,600	2970	1115	29 1/2"	24 1/2"	11 1/2"
H-820 S/S	196,800	3640	1130	33 3/4"	26 1/2"	13"
H-1000 S/S	240,000	4350	1115	33 3/4"	26 1/2"	13"

*Btu based on 2 lb steam, 60 deg. ent air and Rpm as indicated. Above models available with variable speed motors.

VERTICAL DELIVERY MODELS

Available with steel and copper condensers.

Steel Condenser—Heavy, cylindrical steel or iron tubes and headers brazed into a rugged unit of steam-carrying passages. Steel fins metallicly bonded to tubes. Entire condenser coated with lead alloy for protection against external corrosion. Square shape of condenser provides uniform distribution of expansion stresses and absence of strain at joints where injury might result. Parallel alignment of fins eliminates possibility of dirt lodging between fins (as in pie-shaped alignment of round condenser) and clogging condenser.

Cone-Jet Deflectors—Verticals are regularly equipped with radial or spoke-like deflector assemblies illustrated above. Individually adjustable deflector blades make possible delivery of high, narrow jet-like cone of heated air from high elevation . . . or low, broad, softened-velocity cone from low elevation.

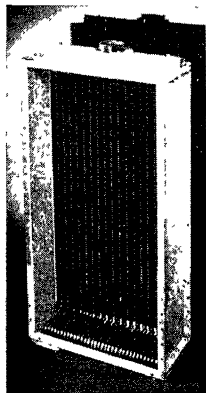
TrunCone Deflectors—Verticals can be furnished with special deflectors for use on units mounted at heights lower than recommended for Cone-Jet Deflectors.

CAPACITIES AND DIMENSIONS (For Steel-Condenser Units)

Model No.	Btu/hr*	Cfm	Rpm	Overall Dimensions (Square)
V-200 S/S	48,000	820	1580	17 1/2"
V-290 S/S	69,600	1220	1130	22"
V-380 S/S	91,200	1830	1720	22"
V-540 S/S	129,500	2570	1130	31 3/4"
V-700 S/S	167,900	3810	1700	31 3/4"
V-760 S/S	182,200	3540	1120	31 3/4"
V-950 S/S	227,600	5120	1720	31 3/4"
V-1030 S/S	247,300	5000	1120	31 3/4"
V-1430 S/S	343,000	6120	1130	43 1/2"
V-2000 S/S	480,000	9450	1120	43 1/2"
V-2510 S/S	602,000	11000	1120	42 1/8"

*Btu based on 2 lb steam, 60 deg. ent air and Rpm as indicated. All but two largest of above models available with variable speed motors

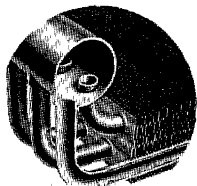
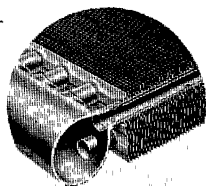
STANDARD BLAST HEATERS



Modine Standard Blast Heaters for heating, ventilating, air conditioning and drying systems are available with steel or copper coils, depending upon application. Modine design features provide great structural strength, light weight and highly effective heat transfer capacity with the ability to handle large volumes of air at lower-than-average static pressure

losses. Wide range of sizes and types to meet practically any temperature, air movement and size requirement.

STEAM DISTRIBUTION TYPE BLAST HEATERS



Cross section of steel supply header and tubes Cross section of copper supply header and tubes

This line of coils is characterized by the uniform distribution of steam throughout the entire heating surface . . . even when steam is partially throttled to meet system temperature demands. Inserted in each condenser tube is a steam-distributing tube having small, accurately sized and spaced orifices along its entire length. Steam entering the distributing tube is uniformly rationed through the orifices into the external or condenser tube . . . then flows as condensate into the return header.

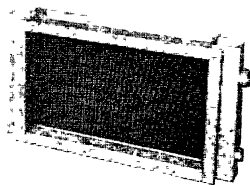
Uniform steam distribution provides a safeguard against freezing of condensate and tube damage, eliminating the need for preheaters or tempering coils. In addition to thus simplifying system design and control, uniform steam distribution solves the problem of stratification in the heated air stream.

Steam distribution type coils can be furnished with copper or ferrous condensers as required by wartime regulations.

VENTILATION HEATERS

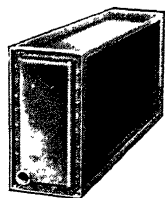
For marine use. Made in Pre-heater and Re-heater types with or without humidifiers. Patented design features permit high heat transfer with small

face area. Casing design reduces weight to minimum without sacrificing strength.



MODINE COOLING COILS

For use in central system cooling and air conditioning plants, Modine Cooling Coils, Cold Water Type, are installed with a blower fan and duct work. Adaptable where cold water or noncorrosive brine is used as the cooling medium. Coils are available in *Cleanable* and *Continuous Tube* types.



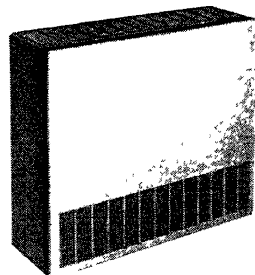
CONVECTORS

Widely used in offices, laboratories, first aid rooms, corridors and aboard Navy and merchant ships. Their popularity over cast iron radiators is due to attractive appearance, saving of floor and wall space, uniform temperatures and adaptability to automatic control. Furnished with copper or steel heating units in a variety of types and sizes.



CABINET UNIT HEATERS

Modine Cabinet Unit Heaters are designed for the heating of offices, lobbies, corridors, auditoriums, etc. Used in conjunction with a steam or hot water system, they eliminate the need for unsightly obsolete radiators. Models include the Floor Cabinet, Wall Cabinet, Ceiling and Recessed types—each available in three capacities: 105, 310 and 450 E.D.R.

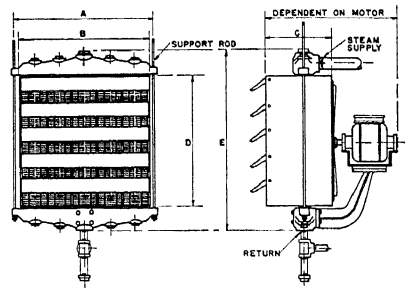
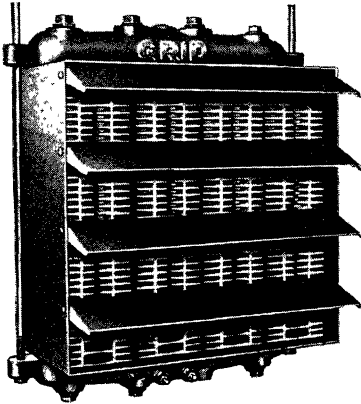


D. J. Murray Mfg. Co.

Wausau, Wisconsin

Offices in Principal Cities

MANUFACTURERS OF THE GRID UNIT



Overall dimensions for installation of Cast Iron
GRID Unit Heater

Now made of high test cast iron instead of aluminum heating sections, to cooperate with the war effort in conservation of vital materials. Patent applied for.

Designed and tested to operate with steam or hot water systems—for steam pressures from 2 lbs to 250 lbs. Engineered along the same lines as the standard GRID Unit which had aluminum heating sections and has been on the market since 1929.

CI (CAST IRON) SERIES GRID UNIT HEATER DATA

Model No.	Dimensions					Motor		Vol. Fan	Capacities 5 lb Steam 60° Air		Approx. Shipping Weight	Pipe Sizes	
	A	B	C	D	E	Hp	Rpm		Btu/Hr	Final TMP		Supply	Ret.
CI 1500	17½	15¾	11½	16	23¾	1/10	1750	1500	76500	107	275	1½"	1¼"
CI 2000	22⅞	21⅝	11⅞	21¼	23¾	1/6	1150	2600	143000	110	440	2"	1¼"
CI 2504	27½	26	13	26	35¼	1/4	1150	3300	206000	117	660	*2"	1¼"
CI 2500	27½	26	13	26	35¼	1/2	1150	4350	224000	107	675	*2"	1¼"
CI 3000	32¾	31⅞	13	31⅞	39⅞	1/2	850	6300	332000	108	1050	*2½"	1¼"
CI 3000	32¾	31⅞	13	31⅞	39⅞	1½	1150	8000	380000	103	1050	*2½"	1¼"

*Furnished also with 2 in. top supply connection inlet.

NO ELECTROLYSIS TO CAUSE CORROSION

Low maintenance expense.
More air changes per hour.
Positive "directed" heat.
No leaks—no breakdowns.

Lower outlet temperature.
Larger air volume.
No soldered, brazed or expanded joints.
Open design that keeps units clean.

Send for complete catalog information

John J. Nesbitt, Inc.

Holmesburg, Philadelphia, Pa.

11 Park Place, New York City

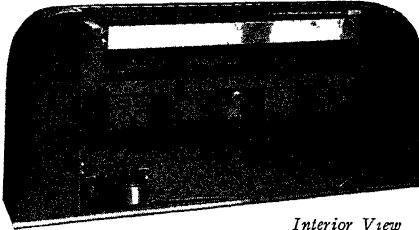
205 W. Wacker Drive, Chicago, Ill.

Manufacturers of

THE NESBITT SYNCRETIZER Heating and Ventilating Unit,
sold by John J. Nesbitt, Inc., and American Blower Corporation;
NESBITT HEATING SURFACE with Dual Steam-distributing Tubes,
NESBITT SERIES H HEATING SURFACE, and
NESBITT SERIES W COOLING SURFACE,

sold by leading manufacturers of fan-system apparatus;
WEBSTER-NESBITT UNIT HEATERS and **AIR CONDITIONERS**
(See page 1039), distributed in U. S. A. by Warren Webster & Company.

All products listed are now available with all-steel coils.



Interior View

NESBITT SYNCRETIZER—Series 400

The last word in heating and ventilating units for schoolrooms, offices, etc., where the continuous introduction of outdoor air is desired. For engineering data, get Publication No. 225-1; for "The Story of Syncretized Air," Publication No. 231-1.

The Nesbitt Syncretizer is available with non-metallic casing. Complete details will be supplied on request.

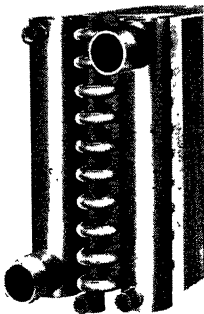
Nesbitt Series B Thermovent

For heating and ventilating auditoriums, gymnasiums, assembly halls, and similar gathering places. Publication No. 227-1.

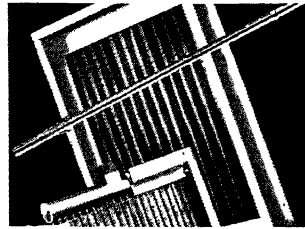
NESBITT COOLING SURFACE

Series W (Water) Surface with exclusive drain feature

For air cooling and cooling and dehumidifying (with cold water) or air heating (with hot water). Constructed of copper tubes and plate-type aluminum fins. Available in either continuous or cleanable tube type, in single sections having one to eight rows of tubes deep, in three fin spacings, in eleven fin widths, and up to sixteen finned tube lengths. Sturdy galvanized casings. For particulars and engineering data send for Publications No. 233 and 233-1.



*Uncoiled Surface
Showing Drain Header*



NESBITT HEATING SURFACES

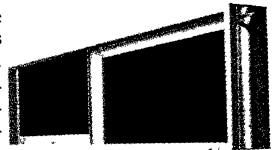
With Dual Steam-distributing Tubes

Copper tube-and-fin surface for low-pressure applications. Perfectly adapted to close, continuous automatic control with modulating steam valves. Steam-distributing tubes within the condensing tubes carry the steam equally to the full section assuring **UNIFORM** discharge temperatures even under a throttled steam supply; eliminating temperature stratification; preventing tube freezing without preheaters; giving ideal system results.

Cased or uncased units of many sizes and capacities. For full particulars and engineering data, send for Publication No. 237.

For above advantages plus uniform distribution in extended fin lengths from 80 to 128 ins., specify *Nesbitt*

Duplex Heating Surface with Dual Steam-distributing Tubes. Publication No. 237.



Nesbitt Series H Heating Surface

A lightweight, enduring, highly efficient blast-coil heating surface designed for use with steam pressures up to 200 lb gauge. Well suited to high-pressure as well as low-pressure applications. Seven types, each in eight fin widths and up to sixteen finned lengths—a total of 784 sizes from which to select. Send for Publication No. 238 for complete engineering data.



THE HERMAN NELSON CORPORATION

General Offices and Factories at Moline, Illinois

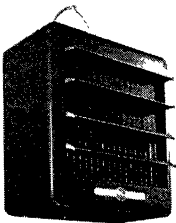
Sales and Service Offices in the Following Cities:

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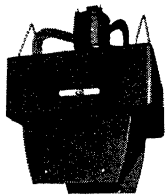
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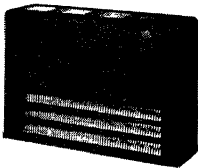
HERMAN NELSON HORIZONTAL SHAFT PROPELLER- FAN TYPE hiJet HEATER

Designed for ceiling suspension, this hiJet Heater projects warm air downward in the desired direction. Incorporates patented stay tube which maintains proper relationship between headers without increasing strain on loops and prolongs life of unit. 48 models, sizes and arrangements.



HERMAN NELSON VERTICAL SHAFT PROPELLER-FAN TYPE hiJet HEATER

This hiJet Heater discharges air vertically downward, or at an angle to vertical in various directions. Long life heating element incorporates Herman Nelson's patented stay tube. Unit can be secured with either high or low velocity discharge. 33 models, sizes and arrangements.

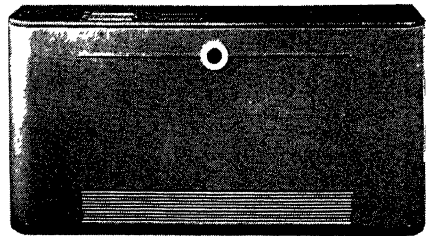
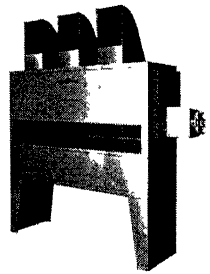


HERMAN NELSON DE LUXE hiJet HEATER

This attractive unit heater is unusually compact and provides excellent distribution and large heating coverage. Incorporates patented stay tube in heating element and light-weight aluminum fan. Her-Nel-Co motor is mounted in end compartment out of air stream. Unit may be placed on floor, wall or suspended from ceiling. 18 models, sizes and arrangements.

HERMAN NELSON BLOWER-FAN TYPE hiJet HEATER

Provides efficient heating of large areas. Can be supplied with by-pass damper if desired. Streamline discharge outlets maintain large air delivery with high velocity. Design of heating element assures durability and contributes to high velocity discharge. For floor, wall, ceiling, or inverted wall mounting. 150 models, sizes and arrangements.



HERMAN NELSON UNIT VENTILATOR

Maintains desired air conditions for school classrooms and rooms in public buildings. Both classroom and auditorium type units have either damper or radiator control. Exclusive "draw-through" design prevents drafts and eliminates overheating. Locating motor in end compartment provides additional space for fan assembly and use of larger fans running at slower tip speeds.

Herman Nelson Unit Heaters and Unit Ventilators are tested and rated in accordance with the Standard Test Code adopted jointly by the Industrial Unit Heater Association and the American Society of Heating and Ventilating Engineers.

THE HERMAN NELSON CORPORATION

Autovent Fan & Blower Division

1809-23 N. Kostner Ave., Chicago, Illinois



AUTOVENT DIRECT DRIVE PROPELLER FANS

Ruggedly constructed for economical operation under severe conditions in industrial applications. Available in wheel diameters from 9 to 72 inches; capacities 450 to 45,000 cfm. Write for literature.



VAPOR-EXPLOSION PROOF PROPELLER FANS

Designed for explosive dust or hazardous fume conditions. Non-ferrous fan wheels. Chemical coatings furnished to requirements. Underwriters Label Class I, Group D, totally enclosed motors. 12 to 36 in. wheels, 800 to 12,500 cfm. "31 Series" fan construction features.

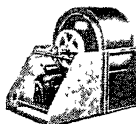
ACID-MOISTURE PROOF PROPELLER FANS

For use where corrosive acid fumes or excess moisture exists. Wheels treated with protective coating for average or severe conditions. From 750 to 12,500 cfm in wheel sizes 12 to 36 inches.



AUTOVENT BELT DRIVE PROPELLER FANS

Developed for use in commercial, industrial and public buildings. . . stock motor with "V" belt drive provides maximum efficiency. Mounted on steel panel for easy installation. Six sizes, 24 to 54 inch wheel diameters with capacities from 5,000 to 23,000 cfm. Commercially quiet operation. All steel construction.



AUTOVENT BELT DRIVE UNIT BLOWERS

Fully self-contained unit including motor, drives and housing; forwardly curved blades; adjustable motor pedestal with vibration dampeners; universal discharge; eight sizes having wheels with diameters of from 12¼ to 30 inches; capacities 1,200 to 8,000 cfm. Compact and sturdy.



AUTOVENT DIRECT DRIVE UNIT BLOWERS

Compact, direct connected, motor driven unit blowers for general ventilating applications, fume hoods, chemical labs, processing, drying, forced draft, toilet ventilation, etc. Universal discharge. Mount on floor, wall or ceiling. Forwardly curved and backwardly curved blade wheels. Can be furnished with special coatings for acid fume conditions. Available in nine sizes: Wheels 6 to 24½ inches in diameter; capacities from 300 to 6,000 cfm.



AUTOVENT TYPE "H" and TYPE "HB" BLOWERS

For heavy duty ventilating and air conditioning installations. Type "H"—forwardly curved blade wheels; Type "HB"—backwardly curved blade wheels incorporating non-overloading power characteristics. Single or double width, Class I or Class II construction; 17 sizes having wheel diameters from 12¼ to 73 inches. Can be furnished to any speed or discharge requirement. Write for new catalog.

The Complete Line of Autovent Propeller Fans and Blowers is tested and rated in accordance with the Standard Test Code adopted jointly by the National Association of Fan Manufacturers and the American Society of Heating and Ventilating Engineers.

The Trane Company

2021 Cameron Avenue, La Crosse, Wisconsin

**MANUFACTURERS OF HEATING, COOLING
AND AIR CONDITIONING EQUIPMENT**

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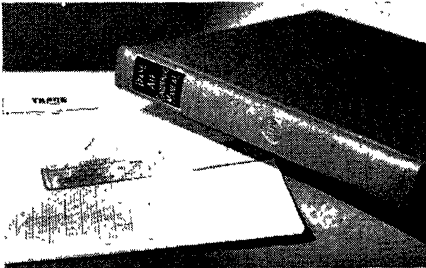
Sales Connections All Over The World

Export Dept.: 75 West St., New York, N. Y.

In Canada: TRANE COMPANY OF CANADA, LTD., Mowat and King Sts., W., Toronto, Ont. (12 Branches)

TRANE EDUCATIONAL MATERIALS

Trane Air Conditioning Manual (New, Enlarged Edition)



Trane offers the engineering profession a comprehensive, straight-forward and unbiased textbook covering the fundamentals of air conditioning. Trane engineers have gathered all available material, sifted and analyzed it carefully to produce in one volume the essence of air conditioning practice. The Trane Air Conditioning Manual not only shows how to design every type of air conditioning system, but also clarifies underlying principles enabling both the student and the engineer to reason out their own problems rather than to blindly follow complicated formulas. Price—\$5.00.

Trane Air Conditioning Ruler and Psychrometric Chart

To solve air conditioning problems with speed and accuracy, The Trane Company has developed the Air Conditioning Ruler and Psychrometric Chart. It eliminates the laborious calculation entailed by out-

moded methods—saves two-thirds of your time in figuring air conditioning problems.

TRANE PRODUCTS

The facilities of the Trane Design Engineering Department are at the disposal of government and industry in the design of new and refined equipment to meet the many demands created by present day needs. Because standard Trane heating, cooling, drying, air handling and related products are used in so many fields of industry, Trane engineers have a thorough knowledge of the equipment requirements of industry.

THE TRANE REPRESENTATIVE

The Trane representative in the field is an equipment expert who functions as a collaborator with professional groups in his territory. He has a complete knowledge of comfort and process applications and is trained to work in conjunction with the consulting engineer, plant engineer, architect, contractor, and governmental agency.

TRANE LITERATURE

A post card to The Trane Company at La Crosse, Wisconsin, or to any of the many Trane Branch Offices will bring you information on the particular Trane product in which you may be interested. Complete engineering application data on all Trane products is available to qualified persons. The list of products across the page suggests the comprehensiveness of the Trane line and also indicates the ability of this organization to design as well as fabricate the exact equipment you need to meet your heating, cooling, drying or air handling requirements.

TRANE PRODUCT GUIDE

AIR CONDITIONERS

(Climate Changers)

Ceiling Type Units
Floor Type Units
Wall Type Units
Process Conditioners
Product Coolers
Spot Coolers
Industrial Units
Sprayed Coil Units
Air Washers

BLACKOUT

VENTILATORS

Exhaust Units
Summer Supply Units
Winter Supply Units

CENTRIFUGAL COMPRESSORS

(Turbo-Vacuum Compressors)

50, 70, 100 and 200
Ton Centrifugal Type,
Hermetically Sealed
Water Chillers

CONVECTORS

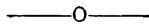
Non-Metallic Cabinet
Convectors
Non-Ferrous Convectors
(For Shipbuilding Field)
Recessed Convectors
Semi-Recessed
Convectors
Wall Type Convectors
Sloping Top Convectors
Floor Type Convectors
Force-Flo Convectors
(Power Driven)

COOLING COILS

Direct Expansion Coils
Water Cooling Coils
Encased Coils
Generator Cooling Coils
Transformer Oil Cooling
Coils
Gas Cooling Coils
Oil Cooling Coils
Drainable Tube Coils
Air Condenser Coils
Special Coils

SYSTEMS

- Heating Systems
- Cooling Systems
- Air Conditioning Systems
- Refrigeration Systems
- Drying Systems
- Ventilating Systems
- Dry Blast Systems



EVAPORATIVE CONDENSERS

Series J Units
(Small Capacity)
Series K Units
(Large Capacity)

EVAPORATIVE COOLERS

Diesel Engine Coolers
Quenching Oil Coolers
Dehumidifying Liquid
Coolers

FANS

Propeller Type Fans
Blower Type Fans
Utility Blowers

HEATING COILS

Steam Coils
Hot Water Coils
Process Coils
Booster Coils
Ventilation Heaters
Special Coils for inclusion
in Processing Equip-
ment

HEATING SYSTEMS

Vapor Heating Systems
Vacuum Heating Systems
Steam Heating Systems
Warm Water
Heating Systems
Industrial Systems

HEATING SPECIALTIES

Float Traps
Bucket Traps
Thermostatic Traps
(for low, medium
and high pressures)
Direct Return Traps
Lightweight Thermo-
static Traps for
Aircraft
Radiator Valves
Temperature
Control Valves
Strainers
Float Vents
Quick Vents

PUMPS

Circulating Pumps
Booster Pumps
Condensation Pumps
Circulators

RAILROAD AIR CONDITIONERS

Electro-Mechanical
Systems
Evaporative Condensers
Ceiling Type
Conditioners
Floor Type Conditioners
Sub-Coolers

RECIPROCATING COMPRESSORS

Freon Condensing Units
Freon Compressor Units

UNIT HEATERS

Projection Type Units
Propeller Type Units
Blower Type Units
Cabinet Type Units

UNIT VENTILATORS

Ceiling Type Units
Floor Type Units

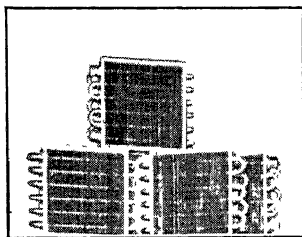
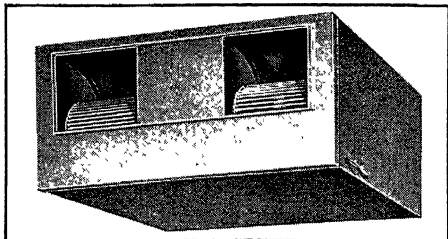
Refrigeration Economics Co., Inc.

Canton, Ohio
RECOY PRODUCTS

RECOY AIR CONDITIONING

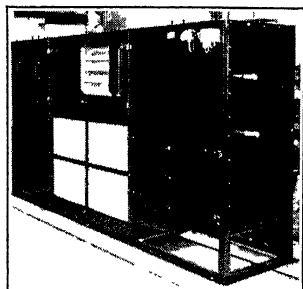
UNITS of the suspended type as shown, or vertical floor type, are made for all season purposes, also for summer cooling or winter heating and humidifying.

Capacities range from one ton up to any size required. Cooling and heating surface, and filter area are liberally proportioned and blowers are of moderate speed, all to insure the highest efficiency and quiet, satisfactory performance. Bulletin "E".



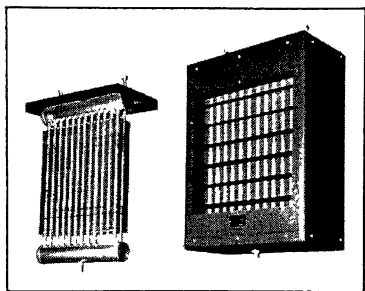
RECOY CONTINUOUS FIN BLAST COILS

for cooling or heating are constructed of copper tubing with aluminum fins, or all steel hot dip galvanized after fabrication and are suitable for use with any cooling or heating medium. Bulletin "F".



RECOY STEEL MILL AIR CONDITIONING

UNITS are for those hot spots with ambient temperatures around 200 degrees such as crane cabs. They are complete package units including all regular air conditioning equipment and controls and in addition evaporative condensers so they may be mounted on traveling cranes where a water cooled unit is impossible. Quotations and data on request.



RECOY BLAST HEATERS have all welded coils and headers so will stand any steam pressure and remain tight for years. Coils are copper tubing with aluminum fins or all steel hot dipped galvanized after fabrication. The entire unit is suspended on the top header and coil is free to expand.

Fan motors are oversize to insure continuous service and fans are guarded.

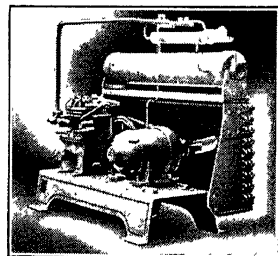
The casings have liberally rounded corners and are beautifully finished in baked crinkle enamel. Quotations and data on request.

RECOY LIQUID COOLING UNITS were developed for the war effort to cool coolant oil for machine tools in arsenals and engine factories. They increase tool productivity as much as 300 per cent and insure greater accuracy of machined parts.

However, they are equally suited for cooling any liquid such as water and brine.

Standard sizes are from $\frac{1}{2}$ hp to 10 hp inclusive, but other sizes are made to specified requirements.

The units are complete, including controls and charge of refrigerant, ready for electrical and liquid connections. Ask for Bulletin H-42.



Factory:
NEWARK, N. J.

L. J. Wing Mfg. Co.
59 Seventh Avenue, New York, N. Y.

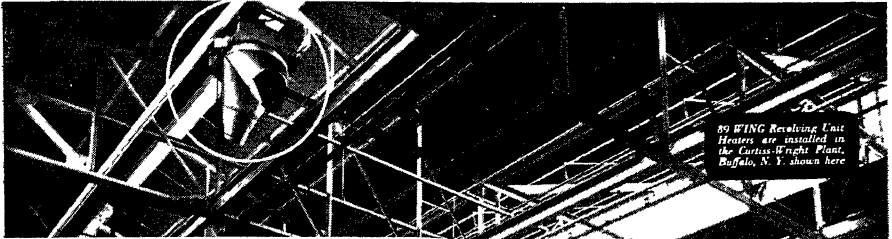
Canadian Factory:
MONTREAL

Branch Offices in



Principal Cities

WING REVOLVING UNIT HEATERS



This innovation in the method of distributing heat produces a sensation in heating comfort never before attained—a sensation of fresh, live, invigorating air.

The fact that the outlets revolve assures uniform and thorough distribution of comfortably warmed air throughout the entire working area, without drafts, hot spots or cold spots.

Such an unprecedented high efficiency in distributing heat is the result of nearly 20 years of constant study by Wing engineers to improve on the Floodlight System of heating originated by WING in 1920. This method projects the heated air vertically downward by means of light-weight, ceiling-suspended unit heaters.

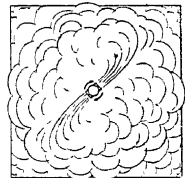
It has needed only this latest refinement of slowly revolving discharge outlets to bring that method to perfection.

The WING Revolving Discharge type supplements the WING line of standard fixed discharge outlets, illustrated and described on the following page.

Bulletin HR-1.

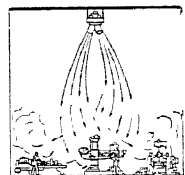
The latest type of WING Unit Heater—with Revolving Discharge Outlets—is just as great a contribution to the art of industrial heating as was the Ceiling-Suspended Unit Heater, originated by WING in 1921.

The area covered by a WING Revolving Unit Heater is slowly swept by the heated air discharged by the outlets which move through an arc of 360 deg. covering every direction of the compass successively.



Top View

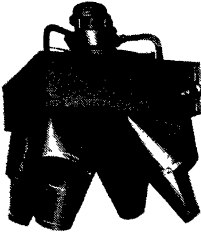
By maintaining an active, constant circulation of air throughout an industrial plant at all times, a new sensation of refreshing, invigorating comfort to workers is produced.



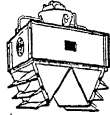
Elevation

WING FEATHERWEIGHT UNIT HEATERS

The first light-weight, ceiling-suspended, unit heater. Eight different designs of outlets meet the requirements of every type, size and height of building or occupancy. Located near ceiling or roof, the accumulation of hot air in the upper spaces, with the accompanying costly waste of heat, is prevented. They project the air, comfortably warmed, downward to the working area. *Bulletin H-9.*



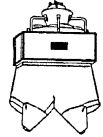
Type "HC" Fixed Discharge



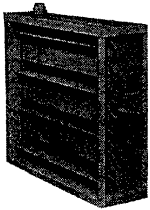
Design No. 3



Design No. 4



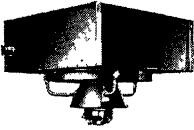
Design No. 8



VARIABLE TEMPERATURE SECTIONS

Invaluable in supplying fresh air for space heating or process work. Close control of the delivered air temperature is obtained without danger of freezing.

Manual or automatic control. *Bulletin HS-2.*



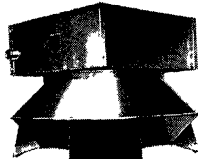
DOOR HEATERS GARAGE HEATERS

WING originated the vertical cone-discharge heater in 1921 and today it is

still applicable for heating the inrush of cold air at large doorways and for garage heating. Often cuts heating costs in half. *Bulletins D-1 and G-1.*

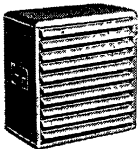
FOR LOW CEILINGS

In this type of WING Unit Heater the position of fan and motor are reversed to meet conditions of ceiling or roof height, form and shape of building, coverage, etc. *Bulletins HR-1 and H-9.*



Type "LC"

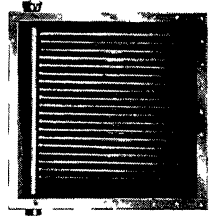
WING UTILITY UNIT HEATERS



A lightweight suspended unit heater for delivering heated air in one general direction. Has the same powerful fan and rugged heating element as WING Featherweight Unit Heaters. This is the latest refinement of the original horizontal light-weight heater which was developed by WING. *Bulletin U-5.*

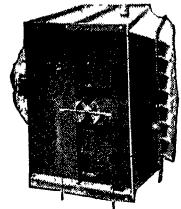
FEATHERFIN HEATER SECTIONS

For heating or cooling air for any purpose by steam, hot or cold water or refrigerant. The heating element is extremely light and, for equal heat transfer, offers little resistance to air flow. Available for any desired final air temperature. *Bulletin HS-2.*



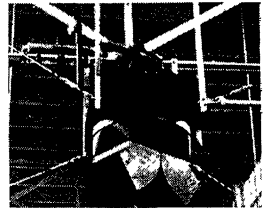
WING INDUSTRIAL FOG ELIMINATORS

Eliminate fog, odor and fumes in dyeing, bleaching and finishing plants, creameries, pasteurizing, bottling, canning and packing plants, chemical works, paper mills, steel pickling plants, etc. No ducts are required. *Bulletin FE-12.*



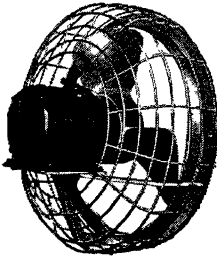
TURBINE-DRIVEN HEATERS

Any WING Unit Heater can be furnished with steam turbine-driven fan for locations where high-pressure steam is available. Photo



shows turbine-driven revolving unit heater. Can also be supplied for fixed discharge or utility type heater. *Bulletin HR-1 and H-9.*

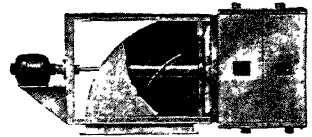
WING-SCRUPLEX SAFETY VENTILATING FANS



A propeller type fan that will deliver air against static pressure, quietly and efficiently.

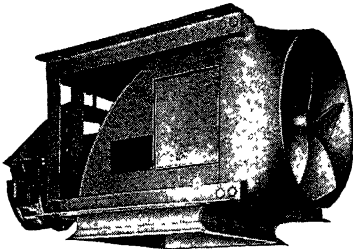
Moves the air forward in straight lines with minimum eddy. Capacities to 100,000 cfm. *Bulletin F-8.*

WING FEATHERFIN PROCESS HEATING UNITS



For manufacturing processes such as drying, aging, etc., requiring the recirculation of the heated air. Motor or turbine located outside air current. *Bulletin P-2.*

WING-SCRUPLEX EXHAUSTERS



For economically moving air wherever ducts are used. It combines the efficient WING-Scruplex Propeller Fan with a housing which places the motor entirely outside the air duct. Motor and drive remain cool and clean and are easily accessible.

The powerful WING-Scruplex Fan delivers high air volume with low power consumption against any pressures for which duct systems should be designed. V-belt or direct drive.

Light, compact and easy to install. *Bulletin 78-A.*

WING SYSTEM OF CONTROLLED COMBUSTION

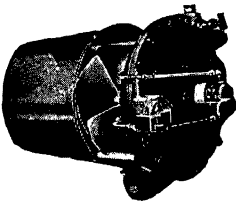
For low pressure heating boilers and small power boilers. Increases capacity and permits use of lowest cost fuel. Includes Type EM Blower equipped with fully enclosed dustproof motor with speed regulating rheostat and automatic control. Eliminates necessity of frequent firing, allowing intervals as great as 24 hours even in zero weather. *Bulletin M-96.*



Installation of Wing System of Controlled Combustion in a large school

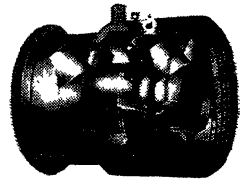
WING TURBINE-DRIVEN BLOWERS

Applied to hand, stoker, oil or pulverized fuel fired boilers, increase boiler capacity, maintain constant steam pressure and permit complete combustion of low-cost fuels. The exhaust steam, free from oil, can be used for heating or processes. *Bulletin T-98.*

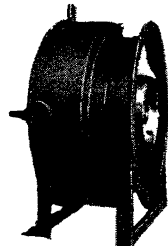


WING MOTOR-DRIVEN BLOWERS

Type COM for static pressures up to 10 in. W. G. and volumes up to 50,000 cfm. Type EMD for moderate static pressures up to $2\frac{1}{2}$ in. Both blowers have fully-enclosed dustproof constant speed motor and built-in adjustable control vanes. Type COM has double-staged axial flow fan; Type EMD, single stage fan. Extremely compact; discharge can be vertical, horizontal or inclined. *Bulletin CO-4.*



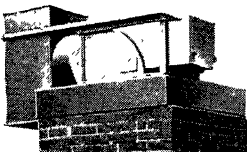
Type COM



Type EMD

WING DRAFT INDUCERS

Installed in breeching or flue, or on chimney top; provide positive, exact draft regardless of weather conditions or inadequate chimney or breeching construction. Suitable for coal, oil, or gas-fired boilers; industrial furnaces and kilns. *Bulletin I-10.*



Chimney-Top Installation

Young Radiator Co.

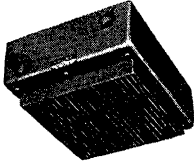
Plant and Executive Offices

709 Marquette St., Racine, Wis.

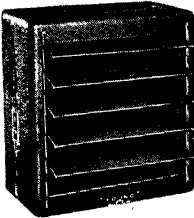
Sales and Engineering Offices in Principal Cities



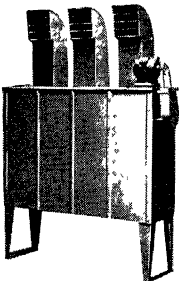
REG U S PAT OFF



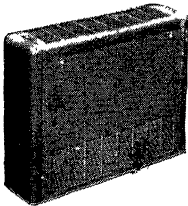
Vertiflow Unit Heaters.



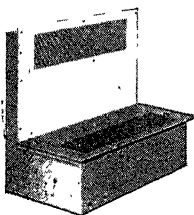
Horizontal Discharge Unit Heaters.



Blower Fan Type Unit Heaters.



Type "FC" Heating Units



Ductless Air Conditioning Units

YOUNG *High Efficiency* UNITS

A complete line of heating, cooling and air-conditioning units. Steel heating elements available. Write for complete information and engineering data.

VERTIFLOW UNIT HEATERS—Propeller Fan Vertical Discharge Type units for ceiling suspension. Heating element split and pitched for proper draining. Eight types of diffusers. 12 models, capacities 30,000 to 480,000 Btu per hour.

HORIZONTAL DISCHARGE UNIT HEATERS—32 sizes of single and twin propeller fan units. Capacities from 18,000 to 658,000 Btu per hour.

BLOWER FAN UNIT HEATERS—Ten models, capacities 120,000 to 800,000 Btu per hour. Also for ceiling suspension.

TYPE "FC" HEATING UNITS—Floor model unit heater in attractive cabinet for offices, corridors, etc. Two fans—operates on steam or hot water.

DUCTLESS AIR CONDITIONING UNITS—Recessed room unit for use with steam or forced hot water systems. Heats, filters, humidifies and circulates air.

"STREAMAIRE" AIR CONDITIONING UNITS—For complete year-round air conditioning. Also available for winter or summer conditioning only. Eight horizontal and eight vertical models. Capacities from 400 to 16,600 CFM.

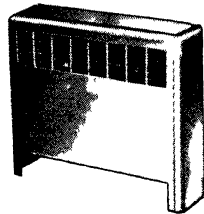
"STREAMAIRE" CONVECTORS—Seven types of steel and non-metallic cabinets, high efficiency heating element. Designed for any type of steam or hot water system.

COMMERCIAL HEAT TRANSFER UNITS—Extended heating or cooling surface for air conditioning units, dryers, etc.

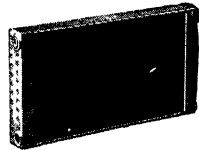
WATER COILS—Continuous tube coils for heating or cooling with water. Cleanable and Drainable types available.

BLAST UNITS—An enclosed surface for forced air heating or cooling systems.

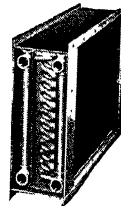
EVAPORATOR COILS—For mechanical refrigeration systems using Freon or methyl chloride.



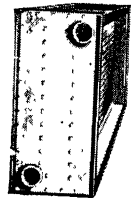
"Streamaire" Convector.



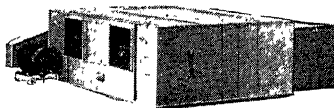
Commercial Heat Transfer Units.



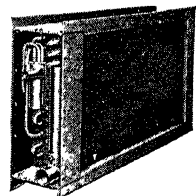
Water Coils



Blast Units



"Streamaire" Air Conditioning Units.



Evaporator Coils

AIR SYSTEM EQUIPMENT

●
Air systems for heating, cooling and ventilating services are produced by grouping various machines and accessories, each performing a function in the complete cycle of the desired operation. The essential parts and accessories described by the manufacturers are contained in the following groups:

AIR FILTERS AND CLEANERS (p. 930-943)

Mechanical and electrical methods of filtering, also air washing and purifying apparatus and their applications.

Technical data on this subject will be found in Chapter 29.

HUMIDIFYING UNITS (p. 944-947)

For supplying moisture to air and controlling its volume as desired for industrial and commercial uses, or for comfort requirements.

Technical data is contained in Chapter 24.

COOLING TOWERS AND SPRAY EQUIPMENT (p. 945-947)

For cooling and reclaiming water used in industrial processes and air conditioning.

Technical data will be found in Chapter 27.

HEAT TRANSFER SURFACES (p. 948-952)

As parts of heating and cooling units, and for separate use in industrial and commercial heating and cooling systems.

Technical data is contained in Chapter 26.

CONDENSING UNITS AND REFRIGERATING MACHINERY (p. 953-961)

For refrigerating processes and for cooling purposes in industrial, commercial and comfort air conditioning service.

Technical data will be found in Chapter 24.

FANS AND BLOWERS (p. 962-975)

For use as separate air circulating equipment, or as parts of heating and air conditioning units.

Technical data is contained in Chapters 23 and 30.

MOTORS (p. 976-977)

Used in conjunction with blowers, fans, stokers, oil burners and other heating, cooling and air conditioning apparatus.

Technical data on motors will be found in Chapter 36.

REGISTERS AND GRILLES (p. 978-990)

Air diffusion equipment for use with heating, ventilating and air conditioning systems.

Technical data relating to this equipment is contained in Chapters 31 and 32.

SHEET METAL AND TUBULAR PRODUCTS (p. 991-994)

Sheets for air ducts and enclosures; pipes for gas, refrigerants, steam, water, etc.
Technical data on pipe and piping is contained in Chapters 15 and 18.

Manufacturer's products shown in this division are designed for specific applications. Consult the Index to Modern Equipment for additional products of these manufacturers.

The Air-Maze Corporation

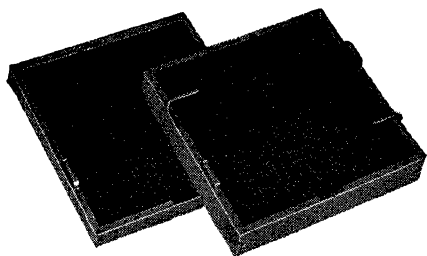
5202 Harvard Avenue, Cleveland, Ohio

ENGINEERS AND MANUFACTURERS OF AIR FILTERS EXCLUSIVELY

DIRECT FACTORY REPRESENTATIVES IN ALL INDUSTRIAL AREAS.

DISTRIBUTORS IN PRINCIPAL CITIES AND TOWNS THROUGHOUT THE UNITED STATES.

During more than 17 years devoted exclusively to air filter engineering and manufacturing, a great deal about the control and elimination of dust, pollens and grit has been learned by AIR-MAZE engineers. Their design and development of a highly efficient type of filter element construction, embodying distinctive advantages, has been considered a worthy contribution to the air filtering science and has resulted in wide acceptance of AIR-MAZE air filters in all fields of application.



2 in. Thick Panel

4 in. Thick Panel

AIR-MAZE Permanent Cleanable Panel Filters

Note Advantages Made Possible by Air-Maze Scientific Construction:

Washable—Need no Replacements—Rigid all-metal baffles of "open" construction permits quick, thorough and economical cleaning. After each cleaning and charging operation, characteristics are same as new filters.

Great Dust Capacity—Unique design of the AIR-MAZE screen wire element provides a vast area of baffles on which collected material can become impinged; thus great capacity is assured.

Vibration Proof—Vibrations in service cannot shake filter media out of position—the uniform density remains *permanently* perfect.

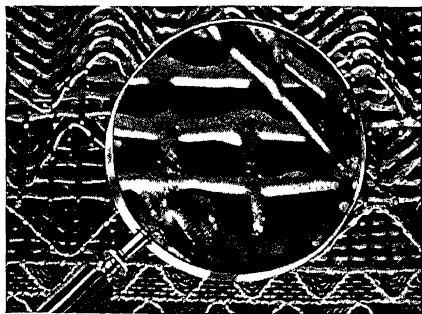
AIR-MAZE Are Listed by Underwriters' Laboratories—When serviced according to the methods approved by the Underwriters' Laboratories, AIR-MAZE panel filters are approved as fire resistant air filters.

Efficiency—Tests under varying conditions, both in laboratories and field operations, show air filtering efficiency of from 98.00 to 99.83 per cent with practical dust.

No Clogging—Scientific and exact progressive density stops larger particles of foreign matter on outer baffles. This, plus "open" type of construction, prevents openings from becoming clogged.

Adaptability—In addition to air conditioning and power equipment installations, AIR-MAZE panel filters are effectively used in humidifiers, water eliminator units, paint spray-booths, oil separators, range canopies in kitchens, and other applications where specific problems and unusual requirements are easily handled by adaptations of the panels. AIR-MAZE panels will be made to fit frames of existing installations and can be furnished with locking handles and latches, snap catches, or with flanged edges and lift handles.

Special frames with new locking clamps are also available.



Magnified Section of "Loaded" AIR-MAZE Air Filter Element. Note that dust has been quite evenly impinged on the wires. No obstructed spaces can be seen. This feature accounts for the Low Pressure Drop and Non-clogging characteristics of AIR-MAZE

TECHNICAL INFORMATION

Sizes—All sizes and thicknesses are available; two and four inch thick panels are the accepted standard. Installations using large sizes of these permanent panels are surprisingly low in cost.

Capacity—Recommended air capacity is $1\frac{1}{2}$ to $2\frac{1}{2}$ cfm per square inch. Thus, the capacity of a 20 x 20 in. panel is 600 to 1000 cfm. Normally, 2 cfm per square inch should be used.

The Air-Maze Corporation

5202 Harvard Avenue, Cleveland, Ohio

Resistance—For 2 in. thick panels the resistance varies from 0.08 in. to 0.10 in. H_2O when handling 2 cfm per square inch of filter area (288 fpm velocity); and for 4 in. thick filters the resistance varies from 0.11 in. to 0.140 in. H_2O at 2 cfm per square inch (288 fpm velocity); the variation being in accordance with the different types of filter media construction available. To obtain specific restriction data write for graphs.

Construction—AIR-MAZE filters are of patented construction consisting of a maze of alternately placed and exactly spaced crimped galvanized wire screens of selected meshes; these are arranged with precision so as to create graduated and progressive density, employing the baffle impingement principle in its highest degree. The filter element is enclosed in a heavy gauge enameled steel frame having two drain holes, to simplify servicing.

EASY TO CLEAN AND CHARGE



Wash out filtered matter in a pan of hot water or under a stream of hot water.



Cut-away View

After cleaning and also after charging, set panel on edge, with open end down, to drain.

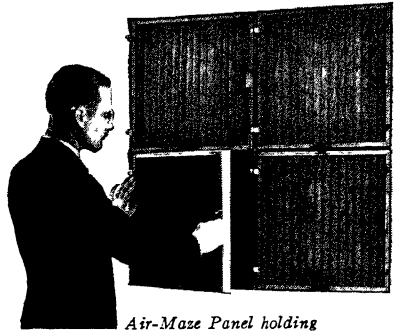


From a flat surface raise one end and let it drop sharply several times. This facilitates drainage.

Cleaning—Simply tap panel a few times on a hard surface to remove heavy accumulations and then wash under a stream of hot water or in a pan of hot water. Steam also cleans the panels quickly and effectively. Be sure filter is dry before charging.

Charging—(For general applications) Spray both front and back of panel with just enough oil to coat the wires. Any inexpensive oil of S.A.E. 40 or 50 viscosity is suitable. An ordinary hand spray gun will do the work splendidly. Or, if desired, panel may be immersed in oil and then thoroughly drained.

AIR-MAZE INSTALLATION FRAMES



Air-Maze Panel holding frames assure efficient, attractive installations.

AIR-MAZE panel holding frames are constructed of enameled heavy gage steel having $\frac{3}{4}$ inch flanged back edge. A thick felt lining on inside of flange insures against air leakage when panels are in place. One frame may be used alone in single panel installations, or a group of frames may be supplied, fixed together; thus a large bank of filter panels may be provided. Every 2 in. frame section is fitted with spring clips as standard equipment; a lift handle is installed on each panel; 4 in. panels and frames have *locking clamps* which may also be used with 2 in. panels at extra cost.

In determining frame sizes, $\frac{5}{8}$ inch is allowed over the EXACT width, and $\frac{5}{8}$ inch over the EXACT height dimensions of the panels. These dimensions include frame edge, clearance and felt edge seals.

Specify AIR-MAZE—for all air filter installations and you will be assured of *efficient, economical performance*. Write for specification bulletin CCC-69.

Engineering Service Available—The Air-Maze Engineering Department will gladly offer installation suggestions for special air filter applications.

Other AIR-MAZE Products—A complete line of circular shaped air filters for use in various Industrial and Automotive Marine and Aircraft applications.

Literature Available—Catalog GPC-740 describing industrial types "A," "B," Greastop, and Kleenflo panel filters. Catalog describing Air-Maze Oil Bath type, Multimaze and Unimaze filters for internal combustion engine, air compressor and blower applications.

AMERICAN AIR FILTER COMPANY INC.

INCORPORATED

673 Central Avenue, Louisville, Ky.

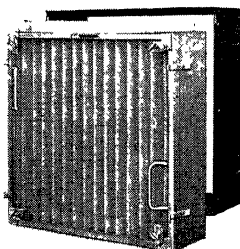
Representatives in Principal Cities

Dust Engineering—Dust Engineering is that branch of applied science which deals with the origin, nature and characteristics of the small solid air-borne particles called "dust," and the development of methods, processes and apparatus for its control or elimination.

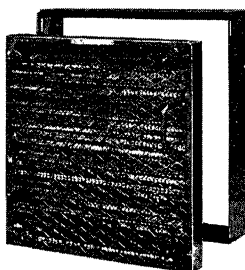
The American Air Filter Company, Inc., has had an important part in advancing the science of Dust Engineering. The efforts of its Research and Engineering Staff for the past twelve years have been devoted exclusively to the study of dust problems and the development of a complete line of air cleaning equipment for modern air conditioning, building ventilation and the control of process dust in industry.

American Air Filter products, therefore, not only embody the knowledge accumulated from years of constant research and the experience gained from designing, building and applying thousands of air filters, but are backed by ample technical and financial resources to insure their outstanding position in the Dust Engineering field.

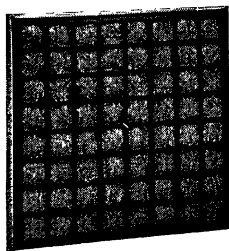
Products—American Air Filters are available for every condition, with operating characteristics and efficiencies to suit specific problems. In general, there are two distinct types based upon the "viscous



Airmat Type PL-24 Filter



M/W 2 Filter



Throway Air Filter

film" and "dry mat" principles. Each type is made in several styles which differ in method of operation, servicing, space required and initial cost to meet the various conditions encountered in air cleaning problems. A discussion of various filter types will be found in the Technical Data Section under "Air Cleaners."

Air filters are generally

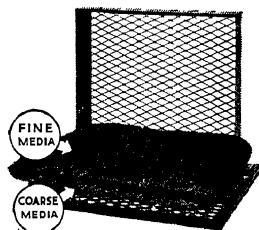
used for the removal of dust, dirt, bacteria and other foreign matter from the air and are applied to general ventilation, modern air conditioning, process dust control; for air compressors and Diesel Engines; mill motors, turbo-generators and other electrical applications; and for air or gas under pressure to remove entrained oil, moisture and dirt.

Air Filters In Air Conditioning—Filtered air is today recognized as essential in modern air conditioning. There are other important factors which contribute to our comfort such as temperature, air movement and humidity, but science today emphasizes the prime necessity of pure air for health and efficiency.

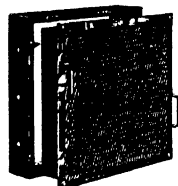
Air cleaners have, of course, always been considered an integral part of large central systems. These are usually of the fully automatic type such as the American Automatic Self-cleaning filter or the self-cleaning Electro-Matic.

There are now available to manufacturers of unit air conditioners moderate priced unit filters such as the Renu filter, the Throway filter, and other types of filters illustrated on this page.

The Renu filter is an entirely new departure in air filter construction. It consists of a permanent metal frame provided with a removable cover and renewable filter pad. The cover



Renu-Vent Filter



Standard Viscous Unit Filter

is easily removed without the use of tools, and filter pad can be lifted out and replaced with a new one at very small expense.

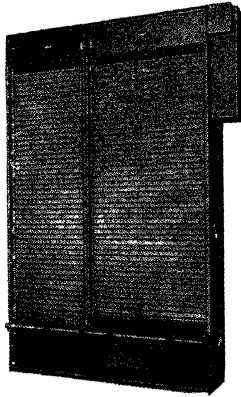
The Throway filter, as the name implies, is designed to be discarded after it has served its maximum period of usefulness and replaced with a new filter unit. The Filter pad is enclosed in a perforated cardboard container which makes it possible to readily dispose of the dirty filter by burning it.

There is probably no single item which costs as little and may mean as much in the design of an air conditioner as air filtration. These units are furnished in any dimensions or shapes desired—usually in units handling 400 cfm and from 2 in. to 4 in. thick. They are usually made in the following sizes—20 x 20 in., 16 x 25 in. and 16 x 20 in. High cleaning efficiencies can be secured, with a resistance to air flow ranging from $\frac{1}{16}$ in. to $\frac{3}{8}$ in. water gauge.

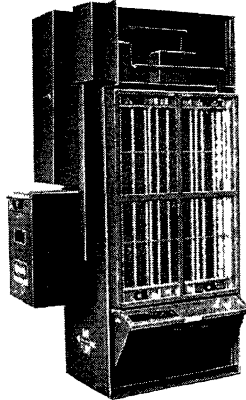
Automatic Self-Cleaning Air Filters—The American line of automatic air filters is among the most complete ever offered. Proved in principle and performance by years of actual service.

The more general use of thermoplastic finishes for refrigerators, stoves, automobiles, and other metal products has created the need for clean air in finishing rooms. This type of finish is hardened by baking, so the product on which it is used must be protected from contamination by dust and dirt from the time it is sprayed until it leaves the oven.

Spray booths exhaust large quantities of air, and if this air is drawn from other parts of the plant, it will contain considerable dust and dirt. If dirt and dust particles are permitted to settle upon freshly sprayed surfaces, they will be



American Automatic Self-Cleaning Filter



Electro-Matic Air Filter

trapped in the semi-tacky coating and cause blemishes in the finished product.

This trouble can be eliminated only by enclosing the finishing room and installing a filtered air supply system with sufficient capacity to provide a constant supply of clean air in excess of the volume exhausted by the spray booths.

High efficiency air filters are needed for this service to minimize rejects and do-overs. The automatic self-cleaning filter has proved the most practical type and is widely used for this application because of its ability to maintain a constant, uniform air volume with the minimum of attention.

American Automatic Filters can be furnished with either Multi-Panel, Type "MS," or Double Duty Type "DD" panels, depending upon the service which they are to perform. Complete engineering data is available.

Electro-Matic Air Filter—Incorporates electrical precipitation as an integral function of an automatic self-cleaning viscous filter to obtain a higher over-all efficiency in dust removal. Its higher efficiency as an air cleaning unit, is due principally to the collection of the finer dust particles and smoke, by electrical precipitation. In combination, these two methods of cleaning air not only give the highest efficiency in dust removal but offer operating advantages found only in the automatic self-cleaning filter.

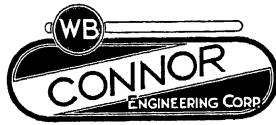
Standard Viscous Unit—The American Unit Air Filter incorporates the time tested unit principle of construction. Each unit consists of a standard steel frame and interchangeable cell equipped with automatic latches to facilitate removal for cleaning and recharging.

Airmat Filter Dry Type—The filtering media in this type is the Airmat sheet, a dry filter mat composed of thin sheets of gauzy, cellulose tissue. The Airmat sheets are supported in screen pockets mounted in a unit frame of box-like construction. These unit frames can be set up to meet any capacity requirement or space condition. Airmat sheets are renewable—their life depending on dust conditions and hours of service.

Airmat filters are used both for comfort and industrial air conditioning. In the latter field they are particularly well adapted for the recovery of valuable dusts and for abating the dust nuisance prevalent in so many industrial plants.

W. B. CONNOR ENGINEERING CORP.

114 East 32nd Street
New York, N. Y.



Representatives
in All Principal Cities

Canadian Representative: Arthur S. Leitch Co., Ltd., Toronto, Ont.

Manufacturers of a Complete Line of Air Recovery Equipment

**Wherever More Outside Air is Used Than Necessary for Oxygen—CO₂ Balance,
Critical Materials, Vital Resources and Energy are Wasted.**

Outside Air is Not Free!

However simple or complex a ventilating system, it represents a considerable capital investment in equipment, a decided operating charge in energy and a vital drain upon natural resources—all expended for the sole purpose of obtaining the kind of air desired and delivering it when and where it is required.

What outside air costs in material and energy—in fans, ducts, dampers, grilles and registers; in boilers, compressors, tempering and cooling coils, filters, air washers and pumps; in thermostats and regulators, steam, water and refrigerant piping, valves and fittings; in electric power, steam, fuel and water; in labor and in operation, maintenance and repair, is prodigious—and it is determinate.

Contrary to being free, air is a valuable commodity whose conservation is imperative. This is why a portion of all conditioned air is usually recirculated. One obstacle alone has heretofore limited the percentage of air that can be recirculated indefinitely—the accumulation of gaseous impurities. These impurities are *not* removable by washers, filters, precipitators or sterilization.

The practical development and application of activated carbon gas adsorption has eliminated this single restriction to the full recovery of heated or conditioned air and *only* the inclusion of adequate gas adsorption makes such Air Recovery possible.

Air Recovery

Ventilation no longer means outside air because all but the new air necessary for metabolism can be obtained by decontaminating recirculated air with activated carbon, thus recovering and conserving the heating and cooling energy already expended upon it. Ventilation is *not* curtailed but new outside air *is reduced*—resulting in a direct saving in conditioning equipment and operation.

Every air conditioning engineer knows the capital cost of equipment and the operating cost in energy demanded by the outside air load. In the average temperature zone in the United States it is 3 tons of installed refrigeration and 100,000 Btu per hour of installed boiler capacity and radiation for each 1000 cfm of outside air made-up. It means, in these days of 24 hour plant operation, the expenditure of 2500 KW hours and 1500 gallons of fuel oil or 9 tons of coal per season for each 1000 cfm.

The curtailment of critical materials and vital resources imposed by our national war emergency has only emphasized the gravity of the waste of conditioned air. The W. B. Connor Engineering Corporation's cooperation with both Federal Agencies and Industry has resulted in the recovery of enormous volumes of conditioned air and has contributed coincidental conservation of materials, power, fuel and labor.

W. B. Connor Engineering Corp. Gas Adsorption Air Recovery Equipment consists of light-weight, removable, perforated fibre, activated carbon filled, adsorption canisters. These are mounted in multiple on one or more supporting manifold plates in such manner that all air to be treated will pass uniformly through the granular carbon media. The assembly arrangement is flexible to suit the space limitations. The resistance to air flow averages only .15 in. wg.

The highly active, specially processed carbon employed will remove from the air passed through it and retain 95 per cent of all entrained gaseous impurities and maintain approximately this efficiency for from 6 months to 2 years depending upon the air contamination. Upon exhaustion the carbon may be reactivated for re-use.

Figure 1 shows a typical canister. It is closed at the top and the inner cylinder is open at the bottom, which opening registers with a corresponding hole in the supporting manifold plate. Figure 2 is a cross-section diagram showing a typical arrangement of canisters for a large system. In this instance, four manifold plates each support 9 rows of canisters, the number of canisters in width, or per row, depending on the total number required. Figure 3 is a photograph of this same arrangement installed. Each canister decontaminates between 25 and 30 cfm of air.

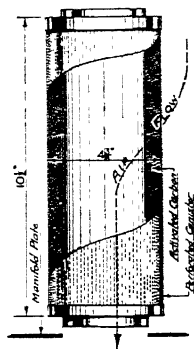


Fig. 1

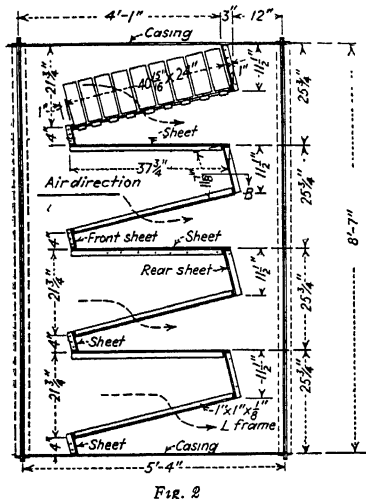


Fig. 2

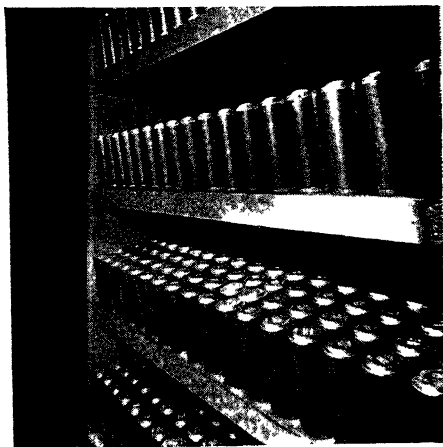
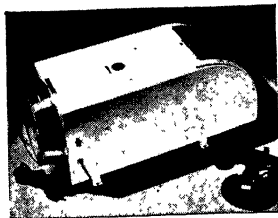


Fig. 3

W. B. Connor Engineering Corp. Gas Adsorbing Air Recovery Systems are covered by U. S. Patents Numbers 2,214,737; 2,303,331; 2,303,332; 2,303,333 and 2,303,334, and others pending.

Among thousands of users—Anheuser-Busch, Consolidated Edison Co. of New York, Coty, Dodge-Chrysler Corp., DuPont Film Mfg. Co., Linde Air Products Co., Merck & Co., Metropolitan Life Ins. Co., Pratt & Whitney Aircraft Corp., Remington-Rand Co., Sperry Gyroscope Co., Standard Oil Companies of N. Y. and N. J., Union Carbide and Carbon Corp., Western Union Telegraph Co., Westinghouse Electric & Mfg. Co., F. W. Woolworth Co.



At the left is an illustration of the Type A-100 F, smallest of the self-contained "package" recirculating air decontaminating units. In its attractive enameled metal cabinet are contained a dust filter, four carbon gas adsorbing canisters, circulating fan and motor. It has a host of practical uses—in homes, offices, doctor's rooms, walk-in refrigerators, etc.

Complete engineering information, surveys or consultation are available without obligation by applying to local representatives or direct to the Home Office.

Coppus Engineering Corporation

339 Park Avenue, Worcester Mass.

MANUFACTURERS OF AIR FILTERS, STEAM TURBINES,
GAS BURNERS, FORCED DRAFT BLOWERS, COOLING FANS

"COPPUS AIR FILTERS PASS CLEAN AIR"

The **Coppus Unit Air Filter** (patent No. 2050508 and other patents pending) is of the dry type using as filter material all-wool felt. It consists of a distender frame (C, Fig. 2), a filter "glove" (E, Figs. 1 and 2) and a retainer grid (B, Fig. 1). The edges of the retainer grid form a reenforced sheet metal box (A, Fig. 1) for protection of the filter element.

The edges of the filter glove are reenforced on all four sides assuring an air tight seal against by-passing of dirty air. By tightening the wing studs which hold the distender frame and the retainer grid together, the filter glove is stretched and held tautly inside of the filter box, giving

the pockets a tapered shape so essential for an even air flow.

This design has the advantage of providing an effective filter area entirely unobstructed by wire or screen supports. Cut, Fig. 3 shows the tapered filter pockets on the clean air side. The filter glove can be readily replaced without removing the unit filter from the installation. No auxiliary frames for insertion of the filter cells are required as the completely assembled unit filters can be bolted together to a filter bank of any desired size.

All metallic parts are rust-proofed and Duco Painted.

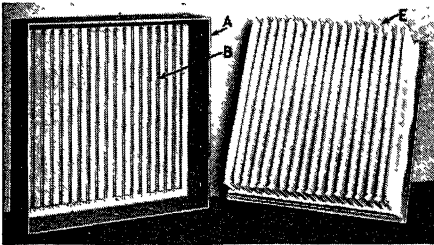


Fig. 1

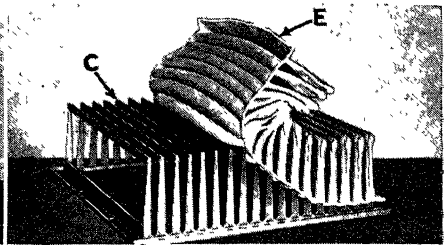


Fig. 2

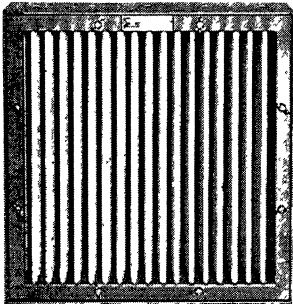


Fig. 3

Specifications

Normal Rating: 800 cfm.

Resistance when clean: 0.2 in. W.G.

Dust Arrestance (cleaning efficiency): 99.61 per cent (Tested in accordance with A.S.H.V.E. Standard Code for Testing and Rating Air Cleaning Devices Used in General Ventilation Work).

Dimensions: 20 by 20 in. by $5\frac{3}{4}$ in.

Weight per unit: 25 lb.

ANOTHER COPPUS BLUE RIBBON PRODUCT

Outstanding Advantages

1. It has an exceptionally high dust arrestance.
2. It maintains a high dust arrestance even under diverse conditions of neglect.
3. Its operation is not impaired by atmospheric conditions.
4. It is a Medium Air Resistance Type (Class C) according to the A.S.H.V.E. Code for Air Cleaning Devices.
5. It is easily and quickly cleaned without removing the filter element.
6. Its cost of upkeep is very low because the *permanent* filter element is reconditioned periodically with a vacuum cleaner.
7. It combines scientific knowledge and practical engineering methods with highest quality of material and workmanship.

Write for Complete Bulletins



*Cleaning Filter
Elements with
Portable Vacuum
Cleaner*

Research Products Corporation

Madison, Wisconsin

RESEARCH AIR FILTERS FOR HEATING AND AIR CONDITIONING
SILICA GEL MOISTURE ABSORBING MATERIAL

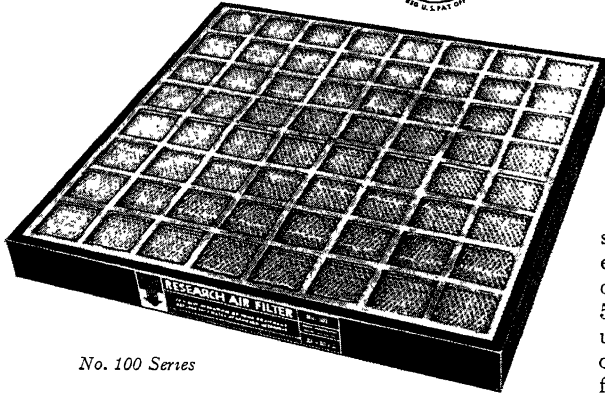
U. S. Patent 2070073

U. S. Patent 2070073

RESEARCH Air Filter



With RiP-CLEAN Features



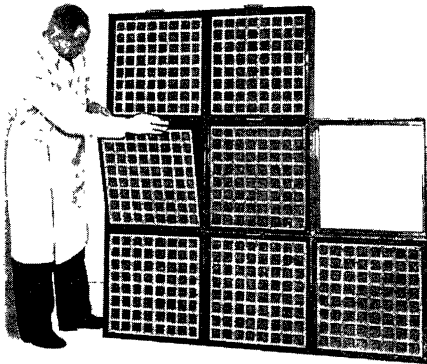
No. 100 Series

Research Air Filters are made of 20 flame-proofed fiber layers expanded into a honeycomb pattern especially treated to catch dust.

When air restriction, due to lint, dirt and dust, hampers air flow, simply tear off two top layers. This removes surface dirt... and can be repeated 5 times, thus tripling the useful life of the filter, without interfering with efficiency.

Research RiP-CLEAN Filter Banks

Send for Research Filter Bank Data Sheets



This new Research Air Filter is ideal for use in filter banks as well as in warm air furnaces and air conditioning units. It is adaptable to both flat and V type banks, providing 25 square feet of dust holding area for every square foot of frontal area.

A Research Air Filter 20 x 20 x 2 in., when tested according to the test code of the American Society of Heating and Ventilating Engineers has an efficiency of 91 per cent, tested with standard code dust. The dust holding capacity with standard code dust is 150 grams per sq ft of filter area, the restriction at this dust load being .2 in. of water.

**Filters Easily Changed
Write For New Data Sheets**

RESEARCH "100" SERIES 2-INCH RiP-CLEAN AIR FILTERS Dimensions, Ratings and Manufacturing Tolerances

Nominal Sizes	Ratings	Actual Dimensions			
		A Width	B Height	C Thickness	D Border
		Tolerances			
		Plus 0.00 In. Minus 1/8 In.	Plus 1/16 In. Minus 1/16 In.	Plus 1/16 In. Minus 1/16 In.	Plus 1/16 In. Minus 1/16 In.
20 x 25 x 2	1000	19 5/8	24 1/8	1 13/16	3/4
20 x 20 x 2	800	19 5/8	19 5/8	1 13/16	3/4
16 x 25 x 2	800	15 15/16	24 13/16	1 13/16	3/4
16 x 20 x 2	640	15 15/16	19 5/8	1 13/16	3/4

These dimensions are used by the trade to order filters and refer primarily to the size of holder into which the filter fits.

Volume of Air
Cleaned at
Velocity
300 F.P.M.
C.F.M.

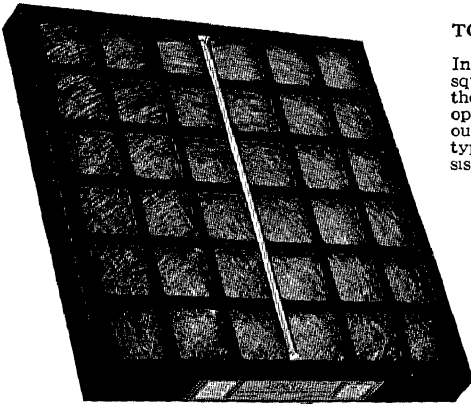
Owens-Corning Fiberglas Corporation

Toledo, Ohio

AIR FILTERS AND FRAMES FOR USE IN RESIDENTIAL, COMMERCIAL *and* INDUSTRIAL HEATING, VENTILATING *and* AIR-CONDITIONING SYSTEMS

FIBERGLAS* **DUSTOP*** AIR FILTERS

*Trademark Reg. U. S. Pat. Off.



TO SAVE CRITICAL MATERIALS

In the new Dust-Stop "War" filter, a square grill of Kraft cardboard replaces the familiar metal grill with round openings. Special dust adhesive previously used is replaced with a standard type filter oil. Properties, except fire resistance remain substantially unchanged

FIBERGLAS DUST-STOP AIR FILTERS will clean air streams of nuisance dirt, dust, and lint . . . and will do it economically and efficiently. Dust-Stops are made from compressed mats of glass fibers, sprayed with binder to hold the fibers in place. The fibers are then coated with a Standard dust-catching filter oil (used on "War" type filters, replacing former special adhesives) suitable for air streams not exceeding 175 F.

Available in Two Standard Types— Fiberglas Dust-Stop No. 1 (1 in. thick) is designed for greatest operating economy in commercial and industrial applications. No. 2 (2 in. thick) is recommended for use in unsupervised installations. It per-

mits longer intervals between replacements. Both may be used in domestic applications.

Economical—Dust-Stop filters cost only 1¢ per CFM as original equipment, and less than 1/10th of 1¢ per CFM to replace. Further maintenance savings can be made by reusing filters after gently rapping out or vacuum cleaning excessive surface dirt accumulations. This practice

may be repeated once or twice before the filter is discarded.

Engineering Service—Owens-Corning Fiberglas Corporation maintains offices in several metropolitan centers where representatives, qualified to assist in the planning of filter installations, are available for consultation.

Standard Sizes for Equipment*

Standard Sizes (Nominal)	Ratings		Average** Resistance Inches Water Gauge Clean
	Cfm	Fpm	
20" x 25" x 1"	1000	300	.062
20" x 20" x 1"	800	300	.062
16" x 25" x 1"	800	300	.062
16" x 20" x 1"	640	300	.062
20" x 25" x 2"	1000	300	.13
20" x 20" x 2"	800	300	.13
16" x 25" x 2"	800	300	.13
16" x 20" x 2"	640	300	.13

*Other standard and any special sizes available.

**Based on standard filters, subjected to minor variations in "war" filters.

Literature—Data sheets on all standard Fiberglas products and applications will be furnished to engineers and manufacturers on request.

Owens-Corning Fiberglas Corp. Branches

ATLANTA, GA.
BOSTON, MASS.
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WASHINGTON, D. C.

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PHILADELPHIA, PA.
PITTSBURGH, PA.
ST. LOUIS, MO.

FIBERGLAS* **DUSTOP*** FILTER FRAMES

*Trademark Reg. U. S. Pat. Off.

Fiberglas Dust-Stop "L" and "V" Filter Frame Assemblies are installed by engineers of commercial and industrial heating, ventilating and air conditioning. Frame members of heavy steel are assembled vertically in combinations to satisfy any CFM and space requirement.

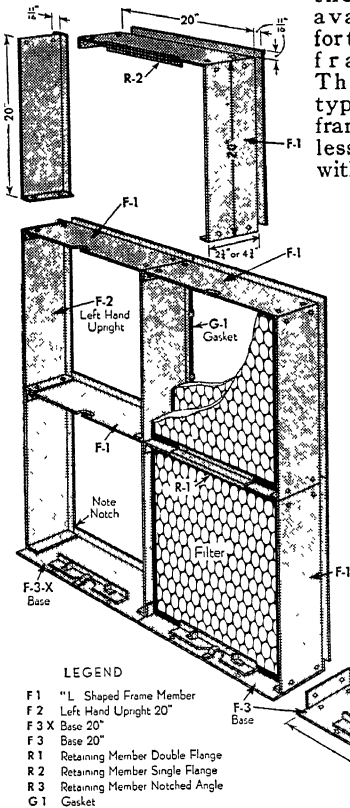
Both types of frames are designed for the convenient and correct handling of Dust-Stop filters. They meet all Fire Underwriters' and local Fire Ordinance requirements, as well as the requirements of Federal Specifications for filter frames.

The choice between the "L" type and "V" type frames is determined wholly by the space available for the filter frames. The "L" type filter frame takes less depth within the

duct or plenum chamber but requires a larger face area for the same CFM capacity. The "V" type frame requires a face area approximately the same as the cross-sectional area of a duct which will handle the volume of air for which the filters are rated.

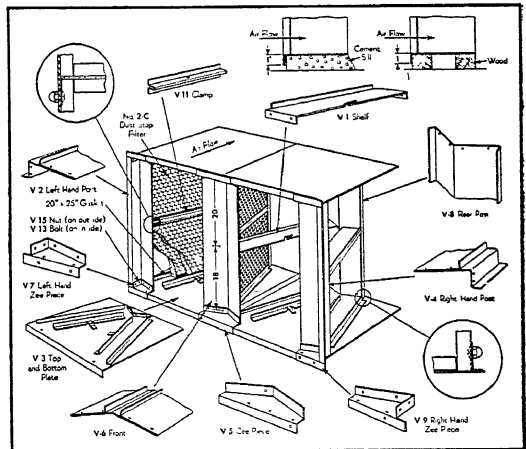
Two Depths of "L" Frames—The "L" frame, two filters deep, is designed to hold two Dust-Stop No. 1 filters in each cell. The "L" frame, four filters deep, holds four Dust-Stop No. 1 filters in each cell. The frame that is four filters deep is identical in every way to the frame two filters deep except that the depth of all parts is 2 in. more. When specifying "L" type frames indicate two-filter or four-filter depth. "V" frame is available, four 1-inch filters deep per cell, only.

The "L" frame uses 20 x 20 in. filters only. The "V" frame uses 20 x 25 in. filters only. Filters are always used two or more in series in each cell.



LEGEND

- F1 "L" Shaped Frame Member
- F2 Left Hand Upright 20"
- F3 X Base 20"
- F3 Base 20"
- R1 Retaining Member Double Flange
- R2 Retaining Member Single Flange
- R3 Retaining Member Notched Angle
- G1 Gasket



ABOVE—Dust-Stop "V" Type Filter Frame.

LEFT—Dust-Stop "L" Type Filter Frame.

When priorities cannot be secured for steel frames—plans and specifications for wood frame assemblies are available. Consult the nearest branch office for complete information.

Staynew Filter Corporation

Air Filters for Every Purpose
Representatives in Principal Cities

6 Centre Pk.

Rochester, N. Y.



AUTOMATIC FILTER

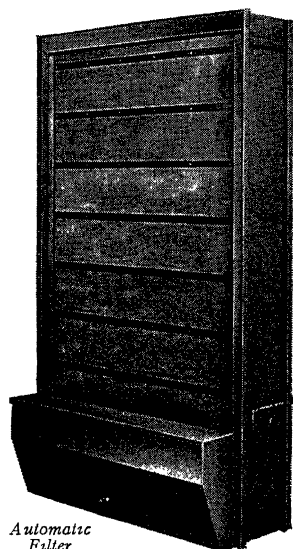
*(For Efficiently Filtering Large Volumes of Air
at Low Cost)*

This latest model Automatic Filter removes dust from the air stream by the impingement principle. Two endless, oil-moistened Filter Curtains of special copper mesh provide four separate stages of filtration. No other filter has the *Double Filter Curtain* feature—double assurance of clean air delivery.

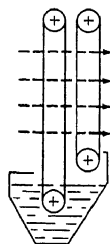
Both Endless Filter Curtains move intermittently at predetermined intervals. One Curtain moves through an oil reservoir. This Curtain removes most dust particles from the air stream. The second Curtain, running dry except for traces of oil from the first Curtain, removes whatever finer dust particles may still be in the air stream.

All excess oil (in which dust particles are trapped), is completely removed from both Curtains by a double series of low pressure compressed air jets. *The Air Jet Cleaner feature is another exclusive Staynew development.*

Direction of Curtain travel is an important, exclusive feature. Both Endless Curtains travel counter-clockwise (air flow from the left). This means that air passes last through the cleaned side of each Curtain—that is, the final stage of filtration in each Curtain has been cleaned either by oil bath, air jets, or both.



Automatic
Filter



Two Endless
Curtains



Air Jet Cleaners



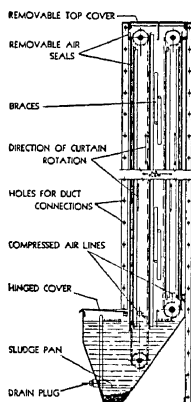
Curtains Travel
Counter-clock-
wise—Air Flow
is L to R in each
Diagram

Specifications:

Two standard widths are built—2 ft 9 in., and 4 ft 3 in., in 41 heights from a 4 ft minimum to 14 ft. Combinations of standard sizes will fit almost any required capacity or installation space. Special sizes are built to order.

Motive power for the Endless Curtains is supplied by a 1/6 hp motor, Telechron-controlled. Speed reduction is accomplished through a standard reducer. Curtain travel is from 7 to 30 seconds each ½ hour, depending on Curtain height. Each Curtain makes one complete revolution every 24 hours.

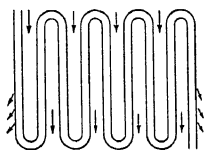
A ½ in. standard fitting is provided at the rear of each section for connection to user's source of air supply. Flow of air to Air Jet Cleaners occurs simultaneously with Curtain movement and is controlled by a Solenoid valve. A pressure reducing orifice lowers any conventional air line pressure to the required pressure of approx. 1 lb.



Section View of
Automatic Filter

STAYNEW DRY TYPE FILTERS

(For removing foreign matter from the air at atmospheric or other pressures, with various types for building ventilation, dust recovery, oxygen chamber and all air cleaning purposes.)



Cross Section Showing Panel and Wire-Klad Unit Construction

The fin or V-type construction is used in all Staynew dry filters. This basic principle permits: (1) a large area of filtering medium to occupy the smallest possible space, and (2) the intake currents to move parallel to the filtering surface at low velocity. Staynew Dry Filters require no adhesive material to catch dust—odorless air is assured. Authorities agree that the positive dry filter is most efficient in stopping the smaller air-borne particles. Staynew dry filters actually prevent the passage of bacteria.

Any filter can be supplied with fire-proofed medium if desirable.



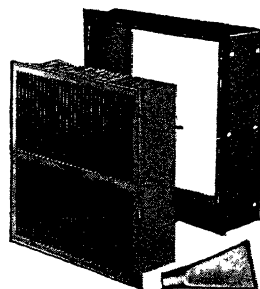
Cross Section of 2 Multi-V-Type Cells in V Formation

EASY TO CLEAN—LONG LASTING

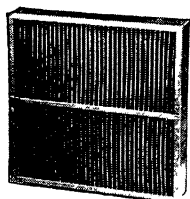
Staynew dry-type filters provide maximum length of life without cleaning or other service due to their extremely rugged construction and fin or V-type design.

Cleaning, when required, is easily effected by use of any vacuum cleaner with special nozzle. (See illustration below.)

Panel Units: Consist of Panel Insert and Frame. The Insert is composed of two rows of 60 hollow loops or fins 6 in. deep, formed of rust-resisting embossed wire mesh, supported by a retaining grate of steel or aluminum and similar spacing grate. Each row of fins is covered with a single piece of Feltex Filtering Medium, a felt-like material specially made for the application. Staynew Panel Filters are designed for the very finest installations where highest possible efficiency is required.



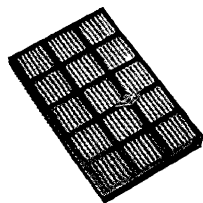
Panel Insert, Frame and Cleaning Attachment



Wire-Klad Filter

Wire-Klad Units: Unique method of construction permits a high efficiency filter at low cost. Fins are reinforced on both sides with screen cloth, producing a rigid, long wearing, flame-resisting filter that may be repeatedly cleaned with vacuum or compressed air, or flushed with water or liquid solvents. Made in 2 in. and 4 in. deep units.

Multi-V-Type Units: Filtering medium (closely pressed cotton fibres between two sheets of cotton gauze), is arranged in patented V-shaped pockets in a fibre-board and pressed metal frame. These patented cells can be quickly and inexpensively replaced when worn out. Their arrangement makes possible an active filtering surface of 27 times face area. In certain installations, the Multi-V-Type is more desirable than the Panel Unit because its construction fits the space better, or because it is lighter in weight per square foot of filtering area, or for reasons of economy. Complete specifications mailed promptly on request.



Single Multi-V-Type Filter

Write for Catalog Mentioning Special Interests

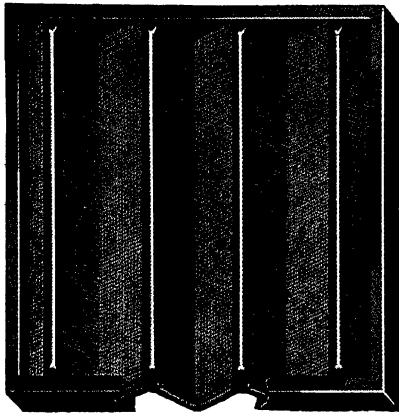
PROTECTOMOTORS ALSO MADE FOR INTERNAL COMBUSTION ENGINES, COMPRESSORS, TURBO-GENERATORS, AIR TRANSMISSION LINES, ETC.

H. J. Somers, Incorporated

Factory and General Office

6063 Wabash Avenue

Detroit, Mich.



All Welded Vee Type

Somers Washable Air Filter

Somers Hair Glass Filters provide everything required in an efficient air-cleaning system. Consider these features: High rating for dust, soot and bacteria separation. Require no adhesive, coating or impregnation. Indestructible in normal service. Minimum Low Pressure Drop. Odorless and non-absorptive. Fireproof; Washable; Do not rot nor disintegrate; Permanent.

Somers Hair Glass Filters consist of a hot galvanized frame holding galvanized wire cloth packed with hair-spun glass strands. The glass strands are flexible, do not break up and cannot be drawn into air stream.

Hair-Glass, being chemically inert, has no facility of absorption; it cannot rust and lasts indefinitely in service. Water either hot or cold may be used to clean it, without impairing its efficiency.

These filters eliminate the necessity, the expense and the inconvenience of periodic replacement.

Somers Washable Air Filter—All Welded Vee Type—Stock Sizes (Partial List)

Frame Size Height and Length In.	Frame Depth In.	Filter Surface Sq In.	For Average Dry Filter Installations CFM	Wet Application where water sprays are applied against filter for hu- midifying CFM
15½ x 24½	3¾	1023	1023	511
15½ x 24½	3¼	1110	1110	555
16 x 21½	3¾	816	816	408
16 x 25	3½	1056	1056	528
16 x 25	3¼	1632	1632	816
16 x 25	3¼	1344	1344	672
16 x 25	3¼	1440	1440	720
16 x 25	3¾	864	864	432
16½ x 24½	3½	800	800	400
18 x 18	3¾	864	864	432
19 x 20	3¾	1482	1482	741
19¼ x 19½	3¼	1039	1039	519
19¼ x 20	3	1039	1039	519
19¾ x 19½	3	936	936	468
19½ x 19½	3¼	1053	1053	526
19½ x 19½	2	480	480	240
19½ x 19½	3	936	936	468
20 x 25	3¼	1170	1170	585
20 x 25	3¾	1800	1800	900
20 x 30	3¾	1800	1800	900
20 x 20	3½	1040	1040	520
20 x 30	3	1560	1560	780
20 x 20	3¼	1200	1200	600
20 x 20	2	480	480	240
20 x 20	3	840	840	420
20 x 20	3	960	960	480
20 x 20	3¼	1320	1320	660
20 x 25	3¼	1560	1560	780
20¾ x 20¼	3	550	550	275

Other sizes from 9½ x 30 to and inclusive of 31 in. x 23¼ also available. Send for complete stock size list. Frames zinc plated for 100 hour salt water spray test. Refill may be inserted if necessary.

Quotations and further engineering data, including master holding frame drawings will be sent on request.

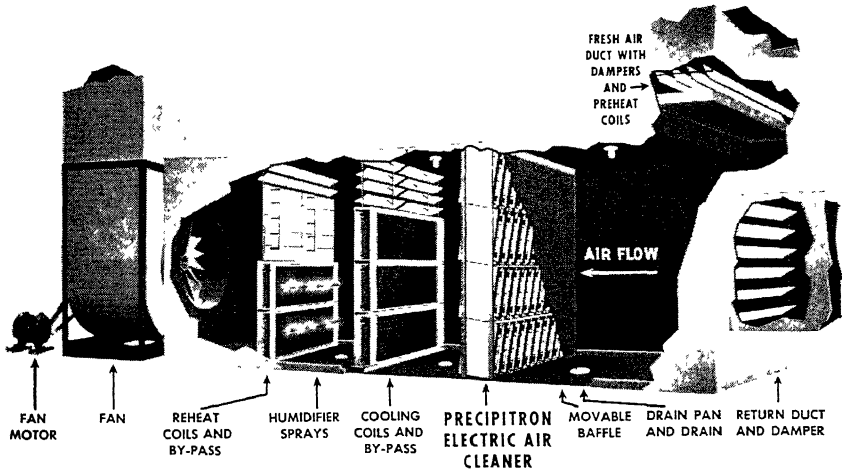
Westinghouse Electric & Manufacturing Co.

Edgewater Park Precipitron Department Cleveland, Ohio

THE PRECIPITRON*

First Commercially Practical Electrostatic Air Cleaner

The Westinghouse PRECIPITRON is the first commercially practical electrostatic method of removing dirt, dust and other air-borne impurities in ventilating and air conditioning systems. The PRECIPITRON—being more efficient than mechanical filters—removes microscopic foreign matter as small as 1/250,000 of an inch in diameter—even freeing the air of tobacco smoke.



The PRECIPITRON provides a complete answer to mass air cleaning jobs in all Commercial, Industrial, and Public Buildings using forced ventilation or air conditioning duct systems.

Applications—Used in industry and production work. PRECIPITRON is serving many manufacturing processes in blackout, air-conditioned plants. Removal of smoke and welding fumes makes possible a considerable reduction in fresh air requirements with consequent savings in cooling and heating costs.

In steel mills and power plants PRECIPITRON is cleaning the ventilating air for rotating electrical machinery. Precision tools, dies and gauges are stored in spaces supplied with PRECIPITRON cleaned air to protect them from abrasive and corrosive dust or dirt. Optical instruments such as bomb sights, binoculars and telescopes are being assembled and maintained to a higher degree of precision with electrostatically cleaned air. PRECIPITRON cleaned air is being supplied to paint spray booths, air cooled radio transmitters, food and drug processing and packaging areas and for the processing and molding of plastic materials. Other fields in which the PRECIPITRON is a proved component of the ventilating or air con-

ditioning system are textile mills, telephone exchanges, hospital operating rooms and commercial and public buildings.

Sizes—The PRECIPITRON is available, complete for installation, to accommodate from 300 cfm (for a single 18 in. cell) to any desired volume through multiple cell arrangements. Cells come in two sizes—18 in. x 8½ in. x 23¾ in. and 36 in. x 8½ in. x 23¾ in. For a 90 per cent efficiency, the 18 in. and 36 in. cells are rated at 300 and 600 cfm respectively. For 85 per cent efficiency, ratings are 375 and 750 cfm. Two sizes of Power Packs: Type S for installation up to 12 36-in. cells and Type L for 12 to 50 36-in. cells.

Advantages—More efficient than mechanical filters. Safe. Easily installed. Non-clogging, and non-varying resistance. Easily cleaned. Passed by Underwriters' Laboratories on standard flame tests for fire hazard on duct installation. Once each month accumulated dirt is washed away.

Information—Westinghouse will gladly provide complete information about the PRECIPITRON. Address your requests to Section G, Precipitron Department, Westinghouse Electric & Manufacturing Company, Edgewater Park, Cleveland, Ohio.

*Trade-mark Registered in U.S.A.

American Moistening Company

ESTABLISHED 1888

Providence, R. I.

ATLANTA, GA.

BOSTON, MASS.

CHARLOTTE, N. C.



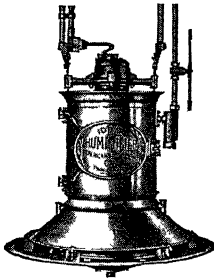
UNIT HUMIDIFYING AND AIR CONDITIONING EQUIPMENT

A few of many AMCO products with a Long Record of Dependable Performance

Sectional Humidifiers.
Amtex Humidifiers.
Hand Sprayers.
Mine Sprays.
Fabric and Paper Dampeners.

Mechanical Psychrometers.
Electro Psychrometers.
Sling Psychrometers.
Hygrometers.

The Amco line of devices for the supply, maintenance and control of humidity is complete in its ability to meet any presented problem of applied humidification. Used independently or as an adjunct to Central Station equipment, these devices automatically maintain any required humidity condition in a capable uniform performance.

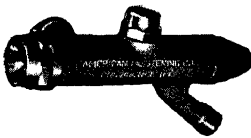


IDEAL HUMIDIFIERS—Senior Type

A high capacity unit for use where conditions require a great amount and good distribution of moisture. Motor driven fan gives wide distribution of atomized spray. Amco heads serve the triple purpose of humidifying, air washing and cooling.

IDEAL HUMIDIFIERS—Junior Type

Similar in construction to Senior Type. Used where medium capacities are required.



AMCO ATOMIZER—No. 4

Quality and quantity of spray are maintained even under adverse conditions because this atomizer is automatically self-cleaning. When the compressed air supply is shut off, either manually or in response to a humidity control, *both* air and water nozzles are thoroughly cleaned.



AMCO HUMIDITY CONTROLS

Compressed Air Operated

An extremely accurate and active device operated by compressed air which assures a regulation of humidity within exceedingly close ranges.

AMCO HUMIDITY CONTROL

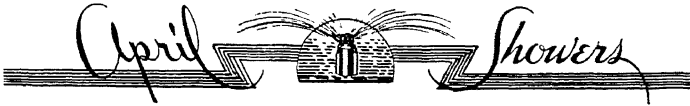
Electrically Operated

Similar in principle to the Compressed Air Type except that the hygroscopic element operates electrical contacts which control the units.

April Showers Company

4126 Eighth Street, N. W.

Washington, D. C.



(Trade Mark Reg. U. S. Pat. Office)

AUTOMATIC EVAPORATIVE ROOF COOLING

FIRE PREVENTION (from external sources) SYSTEM

AN EFFECTIVE WATER INSULATOR for all KINDS of ROOFS

Distributors and Dealers in Principal Cities

- **Solar radiation** is converted to cooling effect, reducing normal heat transmission 70 per cent upward. Entire roof surface temperature is normally held at wet bulb temperature when evaporative factors are favorable. Transmission of solar heat through glass skylights is reduced as much as 85 per cent.
- **Fire Prevention** from external sources is obtained through installation of manual emergency switch. Roof is quickly and completely sprinkled at will, putting out fire-brands, sparks, embers, and maintaining a water covered roof.
- **For Cooling Automatically** upper level, floors, lofts, rooms of buildings. For giant stores, theatres, amusement palaces, stadiums. APRIL SHOWERS is self operating by use of an electric thermal control placed upon the surface of the roof in the SUN. Evaporative cooling effect of liquid applied turns system off. Operating cycles repeat as roof temperature calls for cooling. Water

may be used from city mains, wells, or waste water from condenser units.

- **High Temperature** in lofts, attics, space below roof, or roofing materials is abolished. Roofs of built-up composition, waterproofed with pitch, will remain firm and intact. LIFE of roof is lengthened; disintegration lessened; expansion and contraction which destroys is completely eliminated.
- **Literature Available.** Lists of installations in groups, residences, factories, theatres and amusement places, stores, apartments and hotels. Also circulars: General Description 1940, Residence circular 1941, Industrial Circular 1942. Literature giving engineering data, flow charts, testimonial letters, water consumption figures may be had without charge.
- **Water Consumption** can be adjusted to approximately twenty gallons per day for 1,000 sq ft.

NATION WIDE RECOGNITION GIVEN TO APRIL SHOWERS

ALLIED AVIATION CORP. Glider Plant, North Carolina
BOLLING FIELD Engineering Bldg.
DOUGLAS AIRCRAFT PLANT..... California
GOODYEAR AIRPLANE PLANT..... Arizona
LOCKHEED AIRCRAFT CORP..... California
NICARO NICKEL COMPANY,
..... (Defense Plant Corp.) Cuba
COLUMBIA BROADCASTING Co..... California
R. K. O. PICTURES, INC..... Hollywood, Calif.
20TH CENTURY FOX FILM CORP.
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UNITED ARTISTS BLDG Los Angeles, Calif.
AMBASSADOR HOTEL California
THE BROADMOOR..... Washington
BROOKINGS INSTITUTE Washington
LONGWOOD TOWERS Massachusetts
PICATINNY ARSENAL New Jersey
U. S. NAVAL ORDNANCE PLANT..... Indiana

PORT OF EMBARKATION, WAR DEPT., South Carolina
SELECTIVE SERVICE HEADQUARTERS BLDG.,
U. S. FEDERAL TEMPO NO. 2. BLDG.,
U. S. TREASURY ANNEX
UNITED DRUG Co..... Boston, Mass.
E. F. HAUSERMAN Co..... Cleveland, Ohio
HENRY R. HASSE, INC..... Richmond, Va.
S. S. KRESGE (several stores),
..... Chicago, Detroit, White Plains
ENERGETIC WORSTED MILLS, near Philadelphia, Pa.
HANES HOSIERY MILLS..... Winston-Salem, N. C.
CROWN CORK & SEAL Co..... Maryland
EVANS PRODUCTS Co..... Michigan
HOOD RUBBER Co..... Massachusetts
LINK-BELT Co Philadelphia and Chicago
WESTINGHOUSE, INC..... Pennsylvania

Hundreds of installations, from Boston to Los Angeles have been made. Write for information and address of nearest distributor.

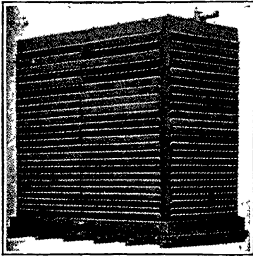
Inquiries will be answered promptly. Estimates free upon request.

The Marley Company

(Fairfax and Marley Roads,) Kansas City, Kansas

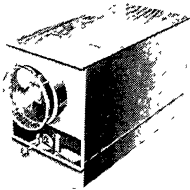
Branches or Agents in Principal Cities

Spray Nozzles and a Complete Line of Water Cooling Equipment



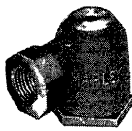
MARLEY NATURAL DRAFT TOWERS

Practically unlimited range of closely graduated sizes, entirely shop fabricated. Minimum initial, maintenance and operating costs. Many exclusive MARLEY advantages. Bulletins 201 and 202.

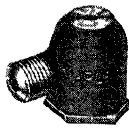


SMALL INDUCED DRAFT TOWERS

Small, self-contained, steel units for 2 to 170 ton service, to go indoors or out. Smaller sizes (horizontal air flow) shipped all assembled, larger ones (vertical air flow) all shop fabricated for fast, easy assembly at location. Bulletins 503 and 505.



MARLEY Small 2-Piece Nozzles for Brine Spraying, Air Washing and Similar uses



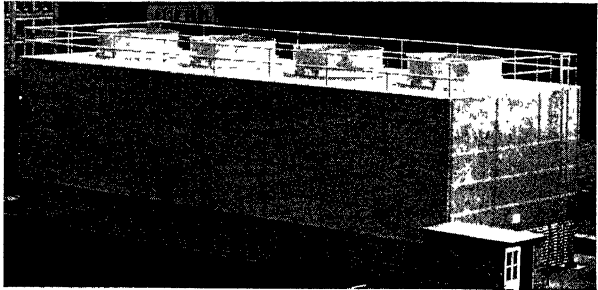
MARLEY Ice-Melting Nozzle for cooling systems using ice.

MARLEY Humidifying Nozzle adds moisture to air in open rooms or duct system.

Also Water Cooling Nozzles for Cooling Towers, Spray Ponds, etc.

MARLEY PATENTED NON-CLOG SPRAY NOZZLES

Made in scores of types and sizes. Practically any metal or alloy the purpose may demand. **Bulletins 101 and 102.**



LARGE MARLEY MECHANICAL DRAFT TOWERS

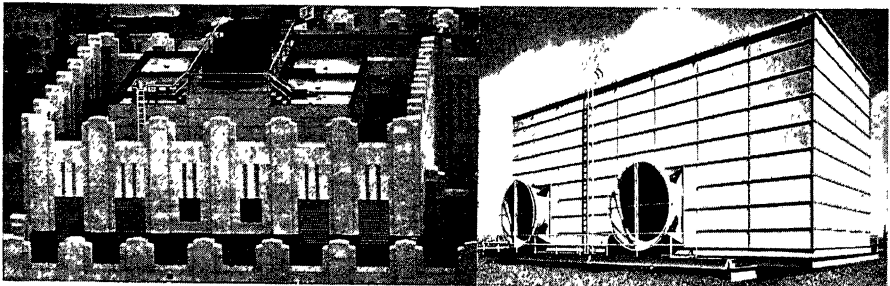
Both Forced and Induced Draft Towers, for heavy duty water cooling services of all kinds. Any capacity, with one fan or many, individually engineered to the exact requirements of each installation. MARLEY patents cover a variety of important features for extreme operating flexibility, high efficiency and economy.

Redwood or Steel are standard materials, Transite and other materials on special order.

"Double-Flow" Induced Draft (below left) for largest capacities. **Bulletin 602.**

"Standard" Induced Draft (above) for usual large-capacity service. **Bulletin 601.**

Forced Draft (below right) for suitable applications in large-capacity service. **Bulletin 600.**

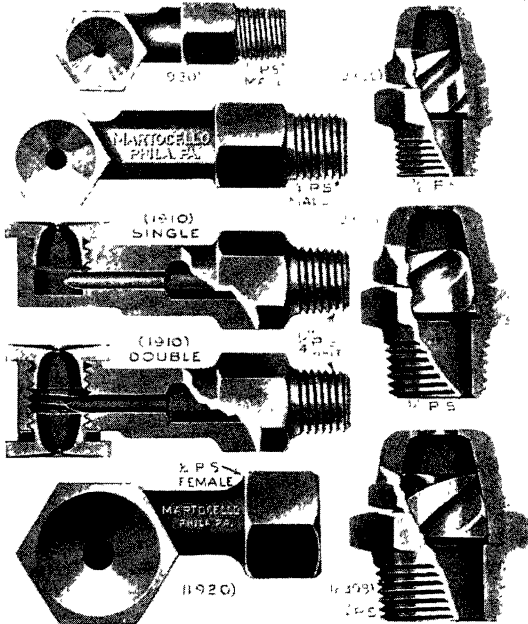


Also Many Other Types of Towers, Spray Ponds and Related Equipment

Jos. A. Martocello & Company

229-31 North 13th Street, Philadelphia, Pa.

ATOMIZING SPRAY NOZZLES



Types of Martocello Spray Nozzles

Martocello Spray Nozzles are broadly used for all types of installations. Manufactured with precision and of a design which has been thoroughly tested for results and durability, they are guaranteed to give you satisfaction.

Successful-Efficient results depend largely upon selecting the proper number and type of Nozzle suitable for your installation. Consult with us.

Martocello Spray Nozzles produce a uniform fine wide spray with minimum friction and at lowest pressure requirements.

For maximum efficiency we recommend Nozzle orifices as indicated in table below. Any reasonable range of capacity for various pressures can be provided.

Send us your specifications as we have types other than shown and we would gladly aid you to make the best selection.

Sizes and Capacities

Pipe Size Inches	Part No.	Diam Orifice Inches	Capacity, Gallons per Minute							
			5 lb	10 lb	15 lb	20 lb	25 lb	30 lb	35 lb	40 lb
1/8	1930	7/64	.22	.29	.34	.39	.44	.49	.54	.59
1/4	1910	13/64	.54	.77	.96	1.13	1.29	1.44	1.58	1.71
1/4	1910 Double	5/32	.86	1.18	1.48	1.76	2.02	2.24	2.44	2.63
3/8	1920	17/64	1.48	1.96	2.38	2.75	3.08	3.36	3.60	3.82
3/8	2300	7/32	1.98	2.63	3.15	3.62	4.05	4.44	4.80	5.13
1/2	2304	5/16	2.66	3.77	4.71	5.52	6.24	6.87	7.47	8.04
3/4	2308	11/32	3.59	4.87	5.92	6.83	7.62	8.33	8.98	9.60

Nozzles illustrated above are made in Brass Forging and machined brass bar stock. Cast Red Brass Nozzles in 1 in. to 2 in. pipe sizes also available. All sizes carried in stock for prompt shipment.

Satisfaction Guaranteed

Acme Industries

Jackson

Michigan

Offices in 30 Principal Cities

REFRIGERATION
AND
AIR CONDITIONING
EQUIPMENT

*Ask for Catalog
on units in which
you are interested*



*May we be of
service through our
Engineering Department*

EVAPORATIVE CONDENSERS

All Prime Surface Cooling Coils—Copper or Steel

AMMONIA CONDENSERS—Shell and Tube—Horizontal and Vertical

FREON CONDENSERS—Shell and Tube—Steel or Copper Tubes

DIRECT EXPANSION WATER CHILLERS

Indirect Air Conditioning and Processing Water

FLOODED WATER COOLERS—Drinking and Ingredient Water

BRINE COOLERS—Steel Tubing or Pipe

HI-PEAK WATER COOLERS—Storage Type, Direct Expansion

CASCADE WATER COOLERS—Aerator Type, Bottling Plants

FINNED COILS—Air Conditioning—Low Temperature

PIPE COILS—Steel $\frac{1}{2}$ in. to 2 in.

HEAT INTERCHANGERS—Refrigerant Suction Line—Liquid to Gas

OIL SEPARATORS—Separators, not Traps

LIQUID RECEIVERS—Refrigerants

ACCUMULATORS—Refrigerants

SURGE DRUMS—Refrigerants

FORCED CONVECTION UNITS—Cold Dispensers

SHELL AND TUBE HEAT EXCHANGERS

Liquid to Liquid—Liquid to Gas, etc.

You don't have to choose between quality and price—BUY ACME

AEROFIN CORPORATION

410 So. Geddes Street
Syracuse, N. Y.

AEROFIN

Standardized Light-weight Heat Exchange Surface

Branch Offices

CLEVELAND, CHICAGO, NEW YORK, PHILADELPHIA, DETROIT, DALLAS, TORONTO

Aerofin is the modern Standardized Light-Weight Encased Fan System Heating and Cooling Surface originated by *Fan Engineers* to meet the present and future requirements of this highly specialized field. All Standard AEROFIN Units are furnished as completely encased Units, ready for pipe and duct connections. The patented casings are built of pressed steel and are exceptionally strong and rigid, protecting the Unit from all the strains of pipe connections and expansion or contraction in service. The casings are flanged on both faces, top and bottom, and template punched for bolting together adjacent Units, or for duct connection

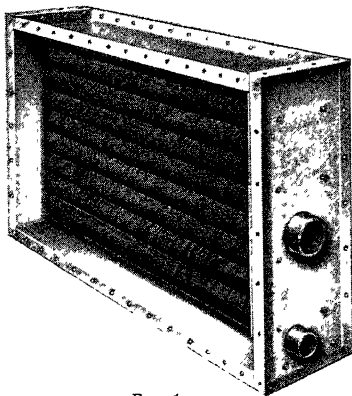


Fig 1

Aerofin Non-freeze heater (Fig. 1) is non-freeze, non-stratifying spiral fin coil built into casing for air conditioning units or for installing in ducts. May be installed horizontally or vertically. Used on any two-pipe steam system for preheating or reheating. Modulating control on preheaters.

Available in 13 lengths and 3 widths, from net face area of 2.76 sq ft to 26.28 sq ft.

Tubing 1 in. O.D. Innertube $\frac{3}{8}$ in. O.D.

Headers—Cast Brass.

Fins—spiral, turned copper.

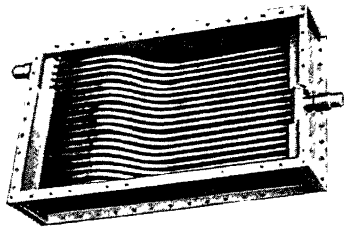


Fig. 2

Flexitube Aerofin (Fig. 2) is distinguished from all other developments by its off-set tubes, so arranged as to absorb all expansion and contraction strains.

Headers—Cast bronze or aluminum.

Tubing— $\frac{5}{8}$ in. O.D. copper, admiralty or aluminum.

Joints—Where admiralty or copper tubes are used together with bronze headers tubes are brazed to headers using Mueller patented joint. Where both aluminum tubes and headers are used tubing is welded to headers.

Casings—Copper, aluminum or galvanized iron.

Design—Constructed with headers on opposite ends making possible installation of units with tubes horizontal or vertical.

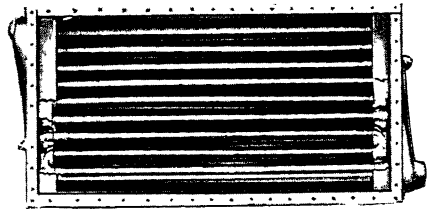


Fig 3

Universal Aerofin (Fig. 3) is distinguished by its "S" bend construction of

tubing, units designed with steel headers on opposite ends, the ends of the "S" bends being connected thereto by compression nuts, the bends taking care of the expansion and contraction of the tubing.

Recommended where close control is desired.

Headers—Pressed steel.

Tubing—1 in. O.D. Copper, admiralty or aluminum.

Casings—Copper, aluminum or galvanized iron.

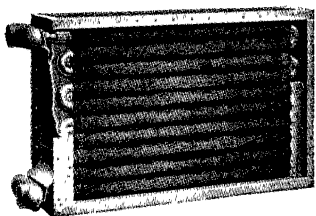


Fig. 4

High Pressure Aerofin (Fig. 4) is of continuous tube design, being recommended where extremely high pressures of steam are used.

Headers—Pressed steel.

Tubing—1 in. O.D. Copper, aluminum or admiralty.

Casings—Copper, aluminum or galvanized iron.

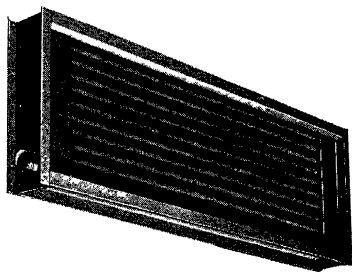


Fig. 5

Booster Aerofin—straight tube type, single pass construction for pressures from 1 to 200 lb gauge.

Headers—cast bronze.

Tubing— $\frac{5}{8}$ in. O.D. copper

Casings—copper, aluminum or galvanized iron. Recommended where small coils are needed or to raise the air temperatures in branch ducts.

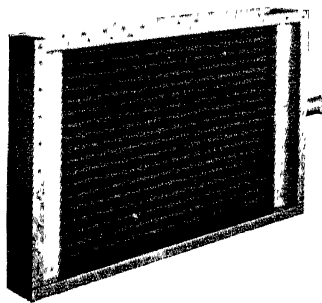


Fig. 6

Narrow Width Aerofin: (Fig. 6) recommended for water cooling or for flooded Freon systems. Made in straight tubes only with headers on opposite ends, joints between headers and tubing being brazed. Construction similar to Flexitube AEROFIN.

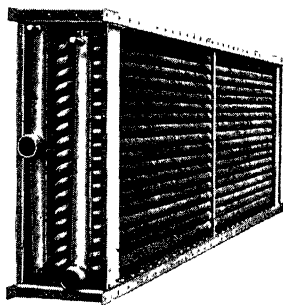


Fig. 7

Aerofin Continuous Tube Water Coils (Fig. 7) are designed for air cooling by circulating cold water through the AEROFIN and air over extended fin surface. Made for either horizontal or vertical air flow.

Tubes and fins are copper, completely tinned with permanent metallic bond

between fin and tubes. Headers are made of one-piece cast bronze and casings of heavy galvanized iron or copper.

Units tested to 1000 lb hydrostatic pressure.

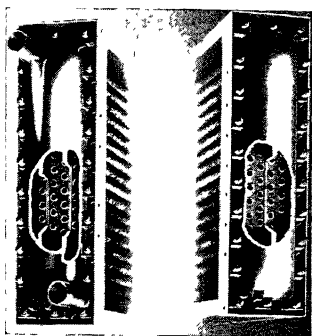


Fig. 8

Aerofin Cleanable Tube Units (Fig. 8) for cooling only and all made with headers removable to permit cleaning out tubes. Recommended for use where sediment or scale forming chemicals are present in the cooling water.

Headers—Cast iron.

Tubing—Copper or admiralty.

Casings—Copper or galvanized iron.

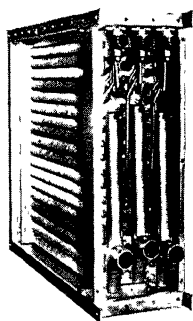


Fig. 9

End plate removed showing distributing and suction headers.

Aerofin Direct Expansion Units: (Fig. 9) Row Control Type—Recommended for use where cutting on or off rows of tubes in direction of air flow is desired. Suitable for use with Freon or Methyl-Chloride.

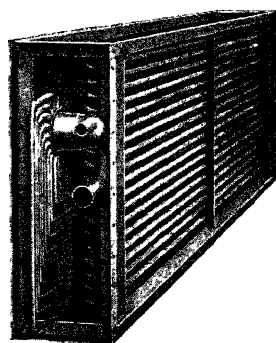


Fig. 10

Aerofin Direct Expansion Units: (Fig. 10) Centrifugal Header Type—Recommended where control of rows in direction of air flow is not required.

Advantages: Weighs but 9 to 16 per cent of same equivalent cast iron surface and occupies one-third of the space. Eliminates expensive foundations and building re-inforcement. Can be suspended from roof beams or trusses if necessary.

AEROFIN Sizes

Flexitube: 13 standard lengths, three widths, one and two rows deep.

Narrow: same as Flexitube.

Universal: 17 standard lengths, two widths, one and two rows deep.

Continuous Tube: 13 standard lengths, three widths, 2-3-4-5 and 6 rows deep.

Cleanable Tube: 17 standard lengths, one width, 2 and 4 rows deep.

Direct Expansion: Row Control—11 standard lengths, 3 widths, 1-2-3 rows deep. Face Control—11 standard lengths, 3 widths, 2-3-4-5-6 rows deep. Centrifugal Header—11 standard lengths, three widths, 2-3-4-5-6 rows deep.

Steel Supporting Legs: 18 in. and 24 in. high. Punched same bolt hole centers as standard casings. Quickly attached. No other foundation required.

Sale: AEROFIN is sold only by manufacturers of nationally advertised Fan System Apparatus. List upon request.

Write Syracuse for Heating Bulletin G-32; Direct Expansion Bulletin DE-34 on refrigeration type units; Continuous Tube Bulletin C. T. 34 for Water Cooling Coils; or pamphlet on Cleanable Type AEROFIN for cooling.

The G & O Manufacturing Company

138 Winchester Avenue

New Haven, Connecticut

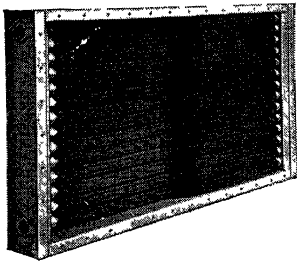


SQUARE FIN TUBING

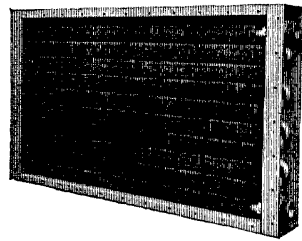
STRAIGHT LENGTHS—U-BENDS—CONTINUOUS COILS

RADIATING ELEMENTS FOR ALL HEAT TRANSFER PURPOSES

G&O Finned Radiation Coils for industrial applications are available in a wide range of sizes. Made of steel in compliance with conservation regulations.



Universal U-102



Standard No 10

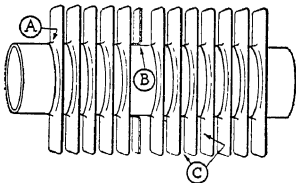
Send for Catalog and Price List

THE use of INDIVIDUAL fins results in high efficiency in heat transfer from primary tube surface to secondary fin surface.

Fins of any size or shape may be obtained giving any desired proportion of primary and secondary surface.

A square fin has about 30 per cent greater surface than a round fin of a diameter equal to one side of the square.

Individual fins permit of any fin spacing; also, of using fins in groups at intervals along tubes.



- A—Generous Fin Collar provides large contact area between Tube and Fin.
- B—Tube expanded against Fin Collar; insures mechanically tight joint, made permanent by bond of high temperature alloy—complete thermal contact.
- C—Free air-flow passages; non-clogging.

STANDARD SIZES

OD. of Tube	Fin Size	Fin Spacing per Inch	Surface per Linear Foot
3/8"	7/8" sq.	6	0.80 sq. ft.
3/8"	7/8" r'd.	6	0.60 sq. ft.
5/8"	1 1/8" r'd.	6	0.87 sq. ft.
3/4"	1 1/2" r'd.	6	1.55 sq. ft.
3/4"	1 3/8" sq.	6	2.40 sq. ft.
1"	2 1/8" sq.	6	4.00 sq. ft.
1 3/8"	2 3/8" r'd.	4	2.33 sq. ft.

Baker Ice Machine Co., Inc.

Omaha, Nebr.

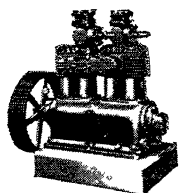
MANUFACTURERS OF INDUSTRIAL AND COMMERCIAL
REFRIGERATION AND AIR CONDITIONING

Sales and Service in Principal Cities

Cable Address. BAKERICE

AUTHORITY ON MECHANICAL COOLING FOR 38 YEARS

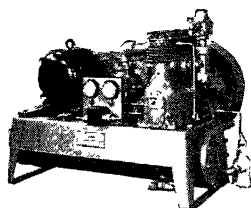
BAKER builds compressors and units for every industrial and commercial application, using either "Freon-12" or ammonia as the refrigerant. The name "BAKER" is your assurance of refrigeration equipment that will operate in these critical times with maximum efficiency and freedom from costly, time-consuming, production-delaying break-downs.



"Freon-12" Compressors

- Four-cylinder type, available in sizes from 3 hp to 60 hp. Semi-steel cylinders and pistons. Counter-balanced crankshaft, precision ground. Nickel-lite connecting rod bearings.

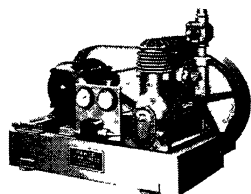
lite connecting rod bearings.



"Freon-12" Water-Cooled Condensing Units

- Complete line of self-contained, automatic units. Sizes range from 3 hp to 20 hp capacity.

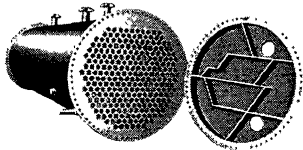
Two- and four-cylinder types. Shell and tube condenser-receiver.



"Freon-12" Compressor Units

- Arranged for use with evaporative type condenser or water cooling tower. Sizes range from 3 hp to 20 hp.

Two- and four-cylinder types. Automatic controls.



Baker Shell and Tube Condensers and Liquid Coolers for Use with Ammonia or "Freon-12"

(1 to 250 tons capacity)

- Made in sizes up to 2500 square feet of cooling surface in single shells. Available for multi-unit installation with special stands to allow compact installation. Supplied in either horizontal multi-pass or vertical type. Heads may be removed quickly and easily for complete

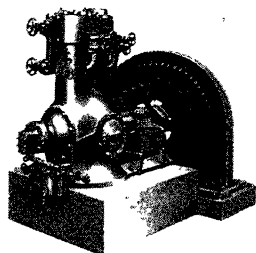
cleaning. Tubes are spaced to provide even gas distribution throughout the shell. All valves of maximum size for greatest efficiency.

Baker Also Manufactures a Complete Line of Industrial-Type Cooling Units, Capped Valves, and Flanged-Type Fittings

SPECIFICATIONS AND SIZES SUBJECT TO CHANGE AS REQUIRED BY GOVERNMENT REGULATIONS

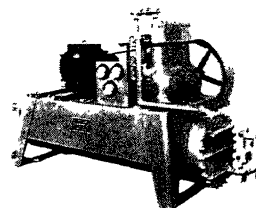
Ammonia Compressors (3 to 100 hp)

- Vertical enclosed, single-acting type. Can be installed in multiple installations. V-belt drive or direct connection to motors or engines. Double suction and capacity reduction in larger sizes.



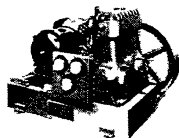
Ammonia Water-Cooled Condensing Units (3 to 15 hp)

- Excellent for low-temperature applications. Shell and tube type condensers with pressure-operated water control valve. Compact design economizes floor space.



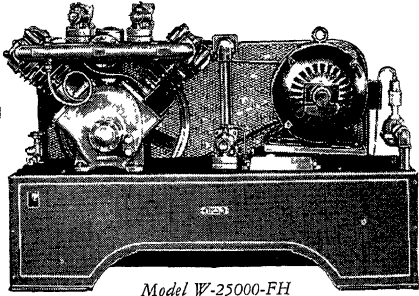
Ammonia Compressor Units (3 to 20 hp)

- Designed for quick installation and ready accessibility to all unit parts. For use with evaporative or separately mounted shell and tube type condenser. Full enclosed automatic motor control with overload and low-voltage protection. Two- or four-cylinder compressor, V-belt drive.



BRUNNER MANUFACTURING COMPANY

UTICA, N. Y., U. S. A.



Model W-25000-FH



COMMERCIAL REFRIGERATION

The Brunner Line of Refrigeration Equipment includes Air Conditioning models up to and including 25 hp for all types of high temperature applications within their capacity, using either "Freon-12" or Methyl Chloride as refrigerant.

BRUNNER DEPENDABILITY is based on time-proven features of design and manufacture . . . all parts are precision machined with extremely close tolerances . . . bronze bearings throughout . . . extra large fin surface on cylinders and heads . . . bellows seal . . . silent eccentric drive (except on 20 hp and 25 hp models, which employ crankshaft) . . . suction and discharge valves in "all-in-one" plate assembly . . . heavy-duty motor with high starting torque . . . adjustable motor base . . . multiple V-belt drive. Throughout, Brunner Refrigeration Units are geared to the demands of *heavy-duty* service.

SPECIFICATIONS					CAPACITIES Air Conditioning Units Based on 76° F Water Temperature "Freon-12" Refrigerant	DIMENSIONS
Model No.	H. P.	Cyls.	Bore and Stroke	R. P. M.	B. T. U. per Hr 40° Evap Temp	L. W. H.
W 300-FH	3	4	3¼ x 2¼	260	38547	50" 24" 28¾"
W 500-FH	5	4	3¼ x 2¼	420	62270	50" 24" 28¾"
W 750-FH	7½	4	4¼ x 3	260	91526	71" 29½" 38½"
W 1000-FH	10	4	4¼ x 3	350	123211	71" 29½" 38½"
W 1500-FH	15	4	4¼ x 3	525	184815	71" 29½" 38½"
W 20000-FH	20	4	4¼ x 5	435	255046	73" 33¼" 48¾"
W 25000-FH	25	4	4¼ x 5	540	316652	73" 33¼" 48¾"

Additional air and water cooled models from ¼ h p for commercial and industrial applications.

The Brunner Field Sales Organization is available in all parts of the country, backed by outstanding achievements in engineering, and adoption of modern methods and design of air conditioning equipment.

Installation of Brunner refrigerating units is insurance of the finest quality materials and workmanship—plus the highest efficiency possible in modern design and manufacture.

FREE . . . COMPLETE ILLUSTRATED CATALOG
with large section devoted to ways of selecting the proper units for any application.

Curtis Refrigerating Machine Division

of Curtis Manufacturing Company

1959 Kienlen Ave., St. Louis, Mo., U. S. A.

ESTABLISHED 1854

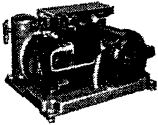
93 Condensing Units
from 1/6 to 50 hp



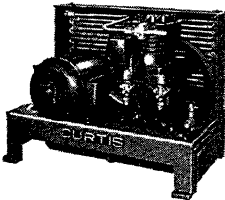
Unit Coolers and
Evaporator Coils

PRODUCTS: Refrigerating Machinery; Forced Draft Cooling Units; Cooling Coils, Condensers, Shell and Tube Coolers, Valves, Fittings and Accessories, Complete Refrigerating Equipment for Dairies, Creameries, Ice Cream Cabinets, Ice Cream Making Plants, Cold Storage Locker Systems, Walk-in Coolers, Drinking Water Systems, Commercial and Low Temperature Cooling, Processing and Air Conditioning Installation, Packaged and Remote Types.

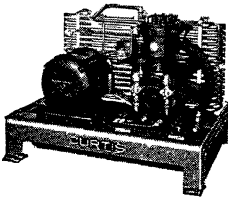
Commercial Refrigeration



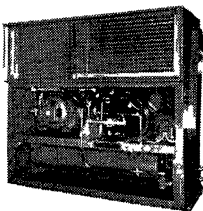
*1/6 to 1/2 hp Self-Contained
Condensing Unit.*



*1 1/2 hp Air Cooled Condensing Unit
Other sizes from 1/4 to 5 hp*



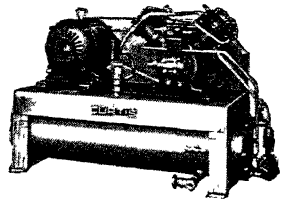
*5 hp Water Cooled (Counterflow)
Condensing Unit Other sizes from
1/8 to 5 hp.*



*7 1/2-10-15 ton Remote or Central
Type Air Conditioner.*

45 air cooled condensing units from 1/6 to 5 hp, inclusive, and 48 water cooled units from 1/8 to 50 hp, inclusive. All models available for either Freon (F-12) or Methyl Chloride. Mechanical advantages include Timken Bearings, Centro-Ring Positive Pressure lubrication.

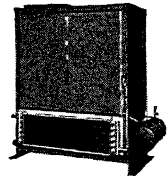
Special models are available for ice cream, frozen food cabinets and for the dairy industry.



*15 hp Cleanable Shell and Tube
Condensing Unit. Other sizes
from 5 to 30 hp.*

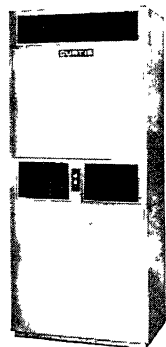
Saturated Air Condenser

For condensing refrigerant vapors economically and efficiently. Saves approximately 95 per cent water cost. Used for air conditioning or commercial refrigeration installations up to 5 ton Capacity.



Air Conditioning

For today's essential Air Conditioning requirements Curtis offers complete packaged, refrigerated air conditioning units, requiring only water and electrical connections to install. Cools, dehumidifies, circulates and filters the air. Eliminates costly installation expense. Adaptable for heating.



*3 and 5 ton Packaged Type Air
Conditioner.*

ALBANY
ATLANTA
BALTIMORE
BOSTON
BUFFALO
CHARLOTTE
CHICAGO
CINCINNATI
DALLAS
DETROIT
KANSAS CITY

Frick Company

(Incorporated)

**Air Conditioning, Refrigerating
and Ice-Making Equipment**

Waynesboro, Penna.

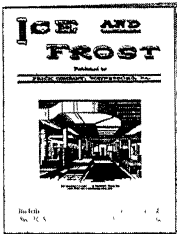
LOS ANGELES
MEMPHIS
NEW ORLEANS
NEW YORK
OKLAHOMA CITY
PALATKA
PHILADELPHIA
PITTSBURGH
ST. LOUIS
SEATTLE
WASHINGTON

Distributors in 150



Principal Cities

AIR CONDITIONING



Ask for Frick Bulletins
503, 504, 505 and 520
on Air Conditioning

Complete Frick systems; also refrigeration for use with equipment supplied by others. Over 1000 installations attest the value of Frick air conditioning systems and those using the Auditorium patents. Successful experience with important Government and industrial war jobs enable us to solve your problems.

AMMONIA REFRIGERATION

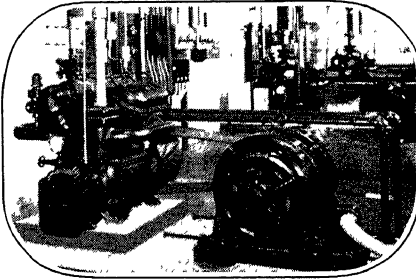
Combined units and vertical enclosed compressors, with two or four cylinders, in sizes from $\frac{1}{2}$ -ton up. Widely used for air conditioning, with material savings. Ask for Bul. 503 on this subject.



Pratt and Whitney use Frick Ammonia Refrigeration for World's Most Accurate Large Air Conditioning System

FREON-12 REFRIGERATION

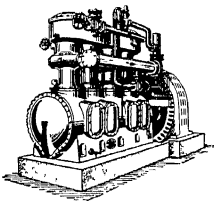
Frick "Eclipse" and larger F-12 compressors form the most complete and efficient line built. Coils, coolers, condensers and controls to suit. Patented Flexo-Seal at shaft, pressure lubrication from submerged pump, capacity controls, and other superior features made Frick machines your logical choice



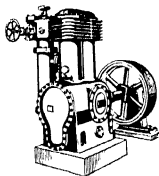
Three 6-Cylinder "Eclipse" Compressors in operation See Bulletin 100

LOW-PRESSURE REFRIGERATION

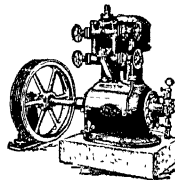
Commercial and industrial units in sizes from $\frac{1}{4}$ hp. up. Charged with either Freon-12 or methyl chloride. Air and water cooled condensers. Coils, coolers, and air conditioners. Get in touch with your Frick Distributor; ask for Bul. 97. Our service includes estimates, layouts, manufacture, installation, maintenance.



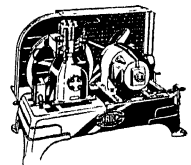
Large
4-Cylinder Compressor
Bul. 651



Enclosed
Freon-12 Machine
Bul. 508



Enclosed
Ammonia Compressor
Bul. 112



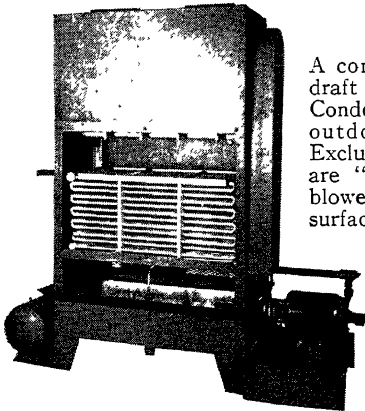
Low Pressure
Refrigerating Unit
Bul. 97

Marlo Coil Co.

6135 Manchester Ave., St. Louis, Mo.

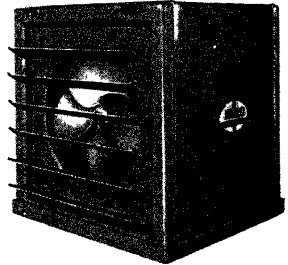
Manufacturers of Heat Transfer Equipment

Brine Spray Units—Unit Coolers—Evaporative Condensers—Low Temperature Units—Air Conditioning Units—Heating and Cooling Coils.



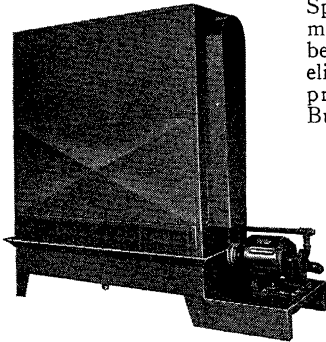
Evaporative Condenser

A combination forced-draft Cooling Tower and Condenser for indoor or outdoor installations. Exclusive Marlo features are "Unidrive", pump-blower motor; all prime surface coils; internal surface covered with corrosion resistant mastic; frame electric welded and galvanized after fabrication. See Bulletin No. 404.



Unit Coolers

In this new model, air is pulled instead of forced through coils, thus utilizing complete coil surface and obtaining greater efficiency. Available in eight sizes, for all common refrigerants. Request Bulletin No. 402.

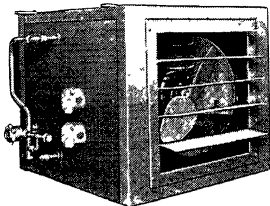
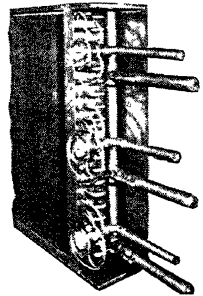


Brine Spray Units

Specially designed to maintain temperature below freezing, and yet eliminate all defrosting problems. Write for Bulletin No. 403.

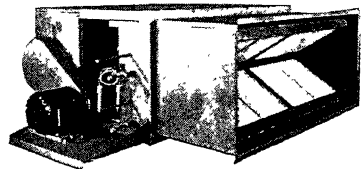
Air Conditioning Coils—Blast Coils

Durably built; conservatively rated; available in materials suitable for any cooling or heating medium. All coils thoroughly dehydrated and tested at 1,000-pound pressure under water. Ask for Bulletin No. 396.



Low Temperature Unit

Designed for sub-zero temperature application. Equipped with the original Marlo electric-heating element for manual or automatic defrosting. Available for any refrigerant. Full details in Bulletin No. 407.



Air Conditioning Units

Air Conditioning Units in either ceiling suspended or floor type. Capacities from 900 cu ft to 12,000 cu ft. Sturdily built on angle welded iron frames of sectional design for easy installation. Bulletin No. 409 gives complete details.

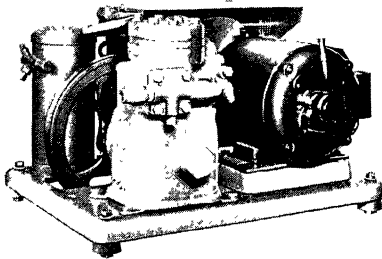
UNIVERSAL

BRANTFORD,
ONTARIO



COOLER

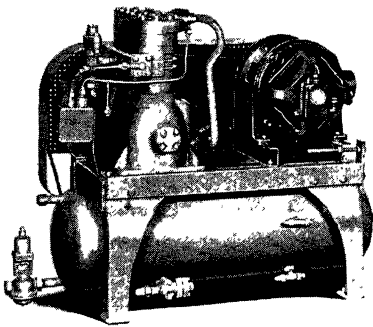
MARION,
OHIO



1/4 HP Self-Contained Type

RESEARCH EXPANDED

- Research and engineering facilities have been greatly expanded. Universal Cooler Corporation's largest and finest corps of engineers now occupy their own building which is an integral part of the 15½-acre plant layout. These engineers are available for discussion or collaboration on special refrigerating problems and correspondence is invited.



5 HP Condensing Unit, Remote Type

PRODUCTION MOBILIZED

- Experience and facilities acquired during 20 years devoted exclusively to the design and manufacture of automatic refrigerating equipment is fully mobilized for production of precision-built war materials. The additional "know how" gained in manufacturing lubricating pumps for bombers, hydraulic mechanisms for aiming artillery, cooling equipment for machine guns, as well as refrigerating units for the Army, Navy and Marines is more reason than ever why manufacturers of refrigeration and air conditioning equipment will want to include Universal Cooler Units in their post-war planning.

● **FROM 1/6 TO 20 HP:** Regular production covers a complete line (1/6 to 20 HP) of commercial condensing units that meet the requirements of a wide range of commercial installations. Design of new units keeps pace with new applications. Efficient, dependable, economical performance of UCC Units is proved by thousands of applications . . . is continuing to win high praise from manufacturers, architects, contractors . . . and users.

Complete Product Data is Available on Request

Automatic Refrigeration Since 1922

The Vilter Manufacturing Company

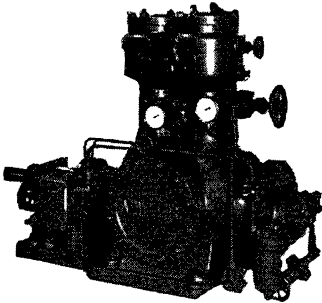
Since 1867

Milwaukee, Wisconsin

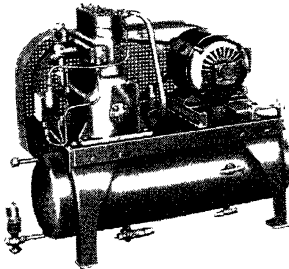
AIR CONDITIONING EQUIPMENT FOR INDUSTRIAL OR
COMFORT COOLING

COMPRESSORS OF MODERN DESIGN

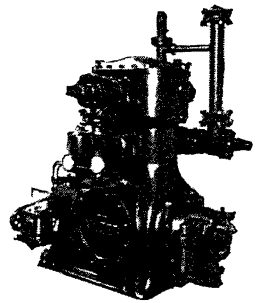
**Ammonia
Compressors**



**Freon or Methyl Chloride
Condensing Unit**



**Freon Compressors
for Large Installations**



Ammonia Compressors—The result of over seventy years of research development and experience gained through thousands of installations of all types, in all industries. Famous for high tonnage capacity at low hp and low operating costs. Built in a wide range of capacities from 2 to 100 tons standard A.S.R.E. rating in Vertical Types; up to 750 tons in Horizontal Type.

Freon Compressors—Embody many outstanding new features that prevent leakage and minimize friction—resulting in extremely low relative hp per ton. Made in capacities up to 150 tons. Capacitrols available at slight additional cost provide flexibility of operation.

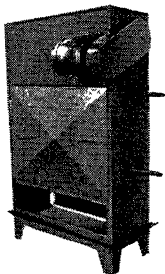
Freon Condensing and Methyl Chloride Units—Self-contained units made in sizes from $\frac{1}{4}$ hp to 30 tons capacity. Embody latest engineering features.

Unit Air Coolers—Available in a wide range of sizes and types for any air conditioning requirement—product coolers, dry coil coolers, spray type coolers, low temperature electric defrosting coolers, and floor or ceiling central system air conditioners.

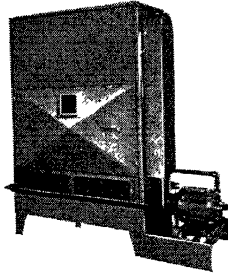
Water Coolers and Condensers—A complete line of shell and tube water coolers, brine coolers and condensers for Freon or ammonia.

UNIT AIR CONDITIONERS

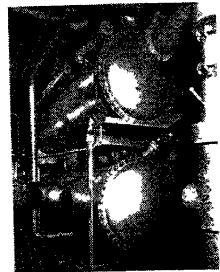
Dry Coil Type



Spray Type



**Shell and Tube
Equipment**



Vilter also builds a complete line of air conditioning coils, evaporative condensers and air washers—and special units for central station comfort cooling systems.

Worthington Pump and Machinery Corporation Air Conditioning and Refrigeration Division

General Offices: HARRISON, NEW JERSEY

ALBANY	BUFFALO	DETROIT	LOS ANGELES	PROVIDENCE	SPRINGFIELD, MASS.
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BOSTON	DALLAS	HOUSTON	PITTSBURGH	SAN FRANCISCO	WILMINGTON, DEL.
	DENVER	KANSAS CITY	PORTLAND, ORE.	SEATTLE	

Representatives in all Principal Cities

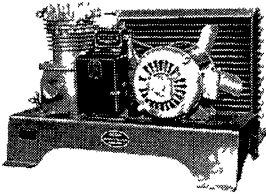
CA3-1

REFRIGERATION SYSTEMS FOR AIR CONDITIONING

Complete refrigerating systems for use with Freon-11, Freon-12, Methyl Chloride, Ammonia, or Carbon Dioxide, either direct-expansion or water cooling applications. A complete line of refrigeration compressors, permitting impartial recommendations. A nation-wide organization of Distributors

in major cities to provide sales and engineering service and plan complete air conditioning systems of the central or unit type. Architects, Engineers, and Contractors are invited to consult with us. Write to Harrison, N. J., or any branch office, for bulletins on these products.

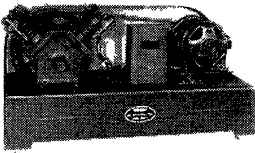
Small Self-contained Units



Freon-12 or methyl chloride condensing units; motors $\frac{1}{4}$ to 2 hp. with air or water-cooled condensers. Used in small air condition-

ing systems, and in commercial refrigeration. Capacities up to 2 tons.

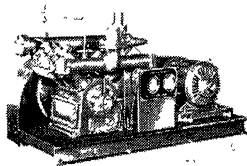
Medium Self-contained Units



Freon-12 or methyl chloride compressor units for use with "shower" condensers or water-cooled condensers.

Features: FEATHER (Pat'd) Valves; automatic capacity control. Capacities 3 to 30 tons.

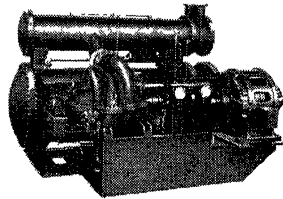
Large Self-contained Units



Freon-12 or methyl chloride compressor units for use with "shower" condensers or water-cooled condensers.

Features: Worthington FEATHER (Pat'd.) Valves; automatic capacity control. Capacities 25 to 100 tons.

Centrifugal Refrigeration Water Cooling Systems

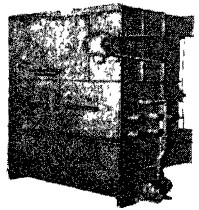


Freon-11 centrifugal compressor, water cooler and water-cooled condenser in compact unit assembly. Electric motor or steam turbine drive. 56 unit sizes . . . 150 to 1200 tons.

Evaporative Type Jacket-Water Cooler

(With By-Pass Section For Automatic Temperature Control.)

Cooling jacket water for diesel and gas engines, air compressors, etc. Ideal for the cooling of quenching oil for tempering steel products. Also for cooling transformer oil to reduce core loss.



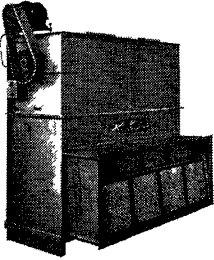
Miscellaneous

High and low side equipment for every purpose.

Worthington Pump and Machinery Corporation

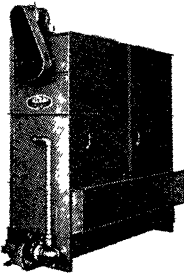
Air Conditioning Units

**For Direct Expansion Freon-12
or Chilled Water Circulation**



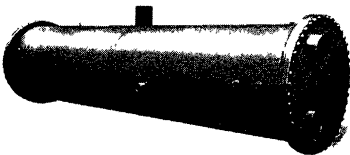
Vertical and horizontal; 500 to 12,000 cfm; large air passages; slow speed, quiet rugged fans; separable sections; readily accessible. The design permits flexibility in installation arrangements.

Shower Condensers



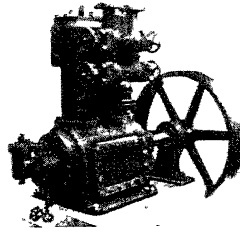
A combined condenser, receiver, and modified cooling tower, in one assembly, for Freon-12 or methyl chloride systems; 2 to 130 tons refrigeration; built in separable sections; all parts easily accessible. Saves 90 to 95 per cent in cost of water.

Horizontal Condensers



Atmospheric drip type, for warm corrosive waters. Double-pipe for closed systems, can be retubed without shutting down. Multi-pass, as illustrated above, for closed systems and space saving.

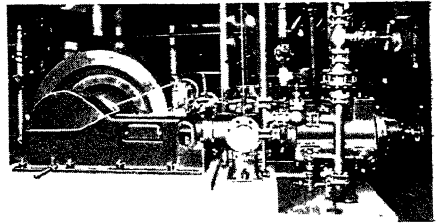
Vertical Ammonia Compressors



Pressure-lubricated; roller main bearings; safety heads; patented Feather Valves; belt drive, or direct-connected to electric motor, diesel

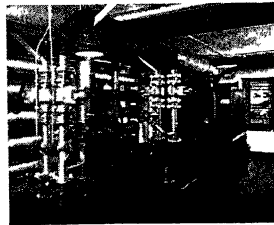
or gas engine; ratings from 2 to 160 tons in one unit.

**Horizontal
Ammonia Compressors**



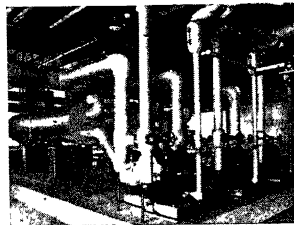
Single and duplex; single-stage and two-stage; belt drive, or direct-connected to electric motor, diesel, gas or steam engine; patented Feather Valves; ratings from 60 to 750 tons. Automatic capacity control features are easily applied. Space requirements vary depending upon type and drive.

Carbon Dioxide Compressors



A series of convenient types and sizes for every requirement is available.

Liquid Cooling Equipment



Various designs of horizontal single and multi-pass types, for a wide range of services; also vertical types. Chillers for

oil dewaxing. Single and double-pipe for milk, wort, chemicals, etc. Cold liquid circulating systems.

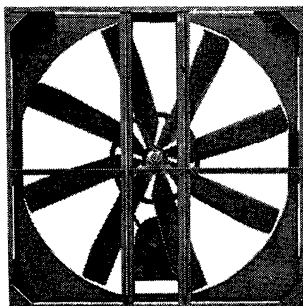
American Coolair Corporation

3606 Mayflower Street, Jacksonville, Florida

Manufacturer of COOLAIR Ventilating and Exhaust Fans

A Pioneer Manufacturer of V-Belt Drive Exhaust Fans

Charter Member: Propeller Fan Manufacturers Association



TYPE S—6 TO 9 FEET

Especially designed for ventilating and cooling in industrial plants and shops, power stations, warehouses and other large buildings—the Type S fan has a heavily braced double frame, special pillow-block ball bearings on each side of fan wheel, 8 to 12 reinforced fan blades and up to 10 heavy duty V-belts depending on size of fan and motor. This fan is usually installed in roof bay or gable, penthouse or outside wall.

QUALITY FEATURES OF COOLAIR EXHAUST FANS

- 1. Built-In Springs on Smaller Motored Units**—dampen vibration and practically eliminate noise for quiet installations by insulating moving parts from frame.
- 2. Light, Compact Fabricated Steel Frame**—fits into many openings where bulky metal housings cannot be used.
- 3. Reversible**—when equipped with reversible motor, fan will blow in or exhaust as desired.
- 4. Ball Bearings in Fan Hub**—eliminate sleeve bearing chatter and end thrust knock—permit operation in any position (specify ball bearing motor for vertical or angle discharge). Use grease, instead of oil, requiring attention not more than once a year.
- 5. Eight Large, Slow-Moving Steel Blades**—instead of 4 or less on cheaper fans—up to 12 blades on type S. models. Low tip speeds for quiet operation and steady flow of air.
- 6. V-Belt Drive**—for high efficiency using small motor for economical operating speed.
- 7. Long Hour Service Motor**—Nationally known makes of motors.
- 8. Certified Air Ratings**—in accordance with Standard Test Code of A.S.H.V.E. and N.A.F.M.
- 9. Full Streamlined Orifice**—(on Type O & OT) avoids "spill-off" at end of blades, reduces power consumption.

TYPE OT—TWIN UNIT

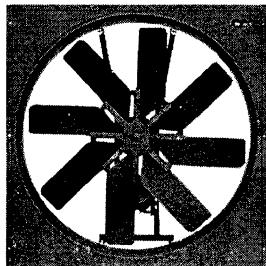
This unique Coolair Twin-Unit is two fans of Type O specifications mounted side by side in one frame and operated by a single motor. Widely used where limited headroom or vertical wall space will not permit the use of a single fan large enough for the job. Especially adapted for installation in partitions, outside wall and on end can be fitted into existing window and door openings. Covered by U. S. Patents 1992112, 2108738 and 219418.

COOLING BY AIR MOVEMENT

Construction engineers and architects as well as production superintendents know that proper ventilation is necessary for top efficiency in employees to insure maximum production. Not so well known is the fact that when heat and humidity induce high body temperatures and perspiration among workers—it takes from four to eight times the volume of moving air to correct this condition than it does for simple ventilation. Satisfactory cooling requires a complete change of air at least once a minute.

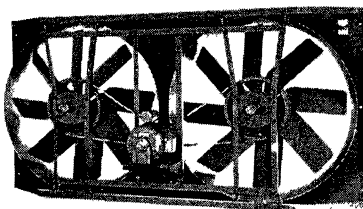
The American Coolair Corporation pioneered in the manufacture of Exhaust Fans for ventilating and cooling. During the past 14 years, Coolair engineers have been directly responsible for many of the developments in this growing field.

In planning a Coolair installation determine the cubic content of the space to be cooled or ventilated and select a fan of ample capacity. Tables of performance data and fan sizes are shown on the facing page—and Coolair's Catalog Pages, sent FREE on request, contain recommended air changes and suggestions for industrial and commercial installations.



TYPE O—26 TO 62 INCHES

Patented built-in springs (on smaller motored sizes) and streamlined orifice combine to make this type quiet in operation. Designed for reversible operation it is equally efficient for vertical or angular discharge when equipped with ball bearing motor. Usually installed in full or section of window opening, outside wall, partition, skylight opening, penthouse—often used in a battery of units for most efficient cooling of large buildings. Covered by U. S. Patents 1992112 and 219418.

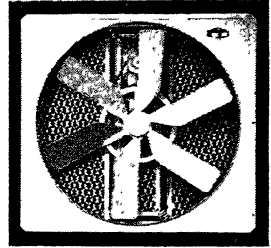


Dimensions in Inches

Fan Size	Overall Height	Overall Width	Overall Depth (Approx)
28-W	31	33	15
2-O	30 $\frac{3}{8}$	30 $\frac{3}{8}$	18
2 $\frac{1}{2}$ -O	36 $\frac{3}{8}$	36 $\frac{3}{8}$	18
3-O	42 $\frac{3}{8}$	42 $\frac{3}{8}$	18
3 $\frac{1}{2}$ -O	49	49	19
4-O	55 $\frac{1}{8}$	55 $\frac{1}{8}$	19
4 $\frac{1}{2}$ -O	61 $\frac{1}{8}$	61 $\frac{1}{8}$	19
5-O	67 $\frac{3}{8}$	67 $\frac{3}{8}$	19
6-S	75 $\frac{1}{4}$	75 $\frac{1}{4}$	28
7-S	86 $\frac{3}{8}$	86 $\frac{3}{8}$	34
8-S	99	99	38
9-S	111 $\frac{1}{8}$	111 $\frac{1}{8}$	38
2-OT	30 $\frac{3}{8}$	61 $\frac{1}{4}$	18
2 $\frac{1}{2}$ -OT	36 $\frac{3}{8}$	73 $\frac{1}{4}$	18
3-OT	42 $\frac{3}{8}$	85 $\frac{1}{4}$	19
3 $\frac{1}{2}$ -OT	49	98	19
4-OT	55 $\frac{1}{8}$	110 $\frac{1}{4}$	22

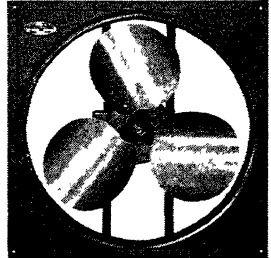
28-W FAN WITH SAFETY GUARD

Coolair's lowest priced belt-drive fan is equipped with built-in springs, adjustable diameter motor pulley and safety guard. This fan can be easily and quickly installed in upper or lower half of any standard window of work rooms or offices where proper ventilation is necessary for health, comfort and efficiency of workers. See tables for data.



DIRECT DRIVE FANS

Four sizes 16 to 24 inches in diameter. General purpose exhaust fan for most commercial and industrial uses. Data on sizes, performance and dimension furnished on request.



COOLAIR AUTOMATIC CEILING & WALL SHUTTERS

Precision-built all-steel shutters that open and close automatically when fan is turned on or off. Ceiling shutters eliminate need of ceiling grille and trap door. Wall shutters give weather protection for fans discharging directly to open air.

Performance Data—Coolair V-Belt Drive Fans

Fan Size		Horse Power	Fan R P. M.	Cubic Ft. Air Per Min.	Fan Size		Horse Power	Fan R P. M.	Cubic Ft. Air Per Min.
28-W	L	$\frac{1}{4}$	515	6000	6-S	B	1	155	35000
2-O	L	$\frac{1}{4}$	570	6200		C	$1\frac{1}{2}$	177	40000
	D	$\frac{3}{8}$	630	6800		C	2	195	45000
						C	3	224	50000
						D	5	270	60000
2 $\frac{1}{2}$ -O	B	$\frac{1}{4}$	411	8000	7-S	B	2	163	49500
	C	$\frac{3}{8}$	454	8800		C	3	176	53500
	D	$\frac{1}{2}$	522	10100		D	5	227	69000
3-O	D	$\frac{3}{4}$	600	11700		D	$7\frac{1}{2}$	262	80000
	B	$\frac{1}{4}$	312	10000	8-S	B	3	147	66500
	C	$\frac{3}{8}$	345	11000		C	5	176	80000
	C	$\frac{1}{2}$	398	12700		D	$7\frac{1}{2}$	220	100000
	D	$\frac{3}{4}$	450	14400		D	10	259	117000
3 $\frac{1}{2}$ -O	D	1	500	16000	9-S	B	5	144	93000
	B	$\frac{3}{8}$	261	13000		C	$7\frac{1}{2}$	165	106000
	C	$\frac{1}{2}$	300	15000		D	10	182	117000
	C	$\frac{3}{4}$	345	17000		D	15	220	142000
	D	1	380	19000	2-OT	B	$\frac{1}{4}$	455	9800
4-O	D	$1\frac{1}{2}$	440	22000		C	$\frac{3}{8}$	500	10800
	L	$\frac{1}{2}$	258	19000		C	$\frac{1}{2}$	570	12400
	C	$\frac{3}{4}$	317	22000	2 $\frac{1}{2}$ -OT	B	$\frac{3}{8}$	359	14000
	D	1	353	25000		C	$\frac{1}{2}$	411	16000
4 $\frac{1}{2}$ -O	D	$1\frac{1}{2}$	405	28000		C	$\frac{3}{4}$	470	18200
	B	$\frac{1}{2}$	224	22800	3-OT	B	$\frac{1}{2}$	312	20000
	C	$\frac{3}{4}$	255	25000		C	$\frac{3}{4}$	360	23000
	C	1	276	27000	3 $\frac{1}{2}$ -OT	B	$\frac{3}{4}$	272	27800
	D	$1\frac{1}{2}$	319	32000		C	1	300	30700
5-O	D	2	355	35000	4-OT	B	$\frac{3}{4}$	235	36000
	B	$\frac{1}{2}$	200	27000		C	1	258	38000
	C	$\frac{3}{4}$	225	30000		C	$1\frac{1}{2}$	317	44000
	C	1	245	33000					
	D	$1\frac{1}{2}$	282	38000					
	D	2	310	42000					
	D	3	355	48000					

B—Very Quiet (Homes, Theatres, Hospitals, etc.).
C—Quiet (Stores, Offices, Restaurants, Barber Shops, etc.).

D—Industrial (Laundries, Factories, Canneries, Bakeries, Pressing Clubs, Garages, etc.).

L—Has adjustable diameter motor pulley for Very Quiet and Quiet performance

Bayley Blower Company

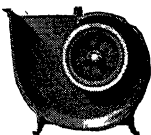
1817 S. Sixty-Sixth Street Branches in Principal Cities Milwaukee, Wis.

Builders of Heating, Ventilating, Cooling, Purifying, Humidifying and Air Washing Equipment; Exhaust and Drying Apparatus, Mechanical Draft and Blast, Fans and Blowers of all Types

Bayley Plexiform Fan:

Is a multi-blade fan for supplying air for heating and ventilating systems, manufacturing processes, drying systems, forced and induced draft systems. It is suitable for handling high or low temperature gases at medium or low pressure. Will deliver maximum quantities requiring minimum space with great economy.

This is a distinct Bayley product, high class material and workmanship, properly designed to avoid excessive vibration and overstressing of parts. Inlets and outlets are properly sized for maximum delivery and maximum efficiency. Fans are furnished in single or double width of any required arrangement and with sleeve or anti-friction bearings.

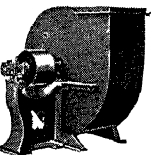


Aeroplex Fan:

Is of high speed design with self limiting power characteristics. Application parallel to the Plexiform Fan. Highly efficient and quiet in operation.

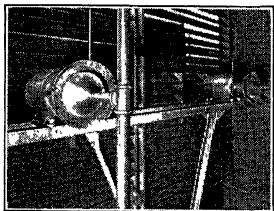
Bayley Exhausters and Pressure Blowers:

Type "B" exhaust fan is for heavy duty, handling refuse from industrial and textile plants. Type "EX" is used in handling smoke, fumes and dust-laden gases. Type "H" for high-pressure work. These units are highly efficient and of high class design and workmanship.



Bayley Turbo Air Washers, Humidifiers and De-Humidifiers:

The Turbo Atomizer used in the Bayley Washer produces a steady, fine spray. Water at low pressure is delivered to the center of a rapidly revolving cone-shaped rotor provided with atomizing pins set in its periphery. This

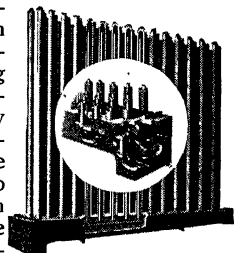


The Bayley Turbo Air Washer Showing Turbo Atomizer and Eliminator

atomizer requires very little attention, and will operate successfully under low water pressure. The orifices are large and this atomizer, unlike high pressure nozzles, cannot clog.

Bayley Chinook Heating Sections:

The Chinook section is used with blast heating, ventilating and drying systems, and is suitable for high or low pressure steam circulation. The base is divided into two chambers. Steam enters (see cut) the lower chamber, rising through $\frac{3}{8}$ -in. pipes located within the $1\frac{1}{4}$ -in. pipes leading from the upper chamber. Condensation takes place in the larger pipes, the water falling into the upper chamber and draining away through the return outlet. The Chinook can be repaired in the middle of the bank without breaking steam connections or taking down a section.



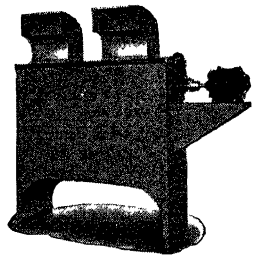
Shipped assembled in smaller sizes, and knocked down in the larger units. May be installed in horizontal or vertical position.

Bayley Chinookfin Heating Sections:

Are the same design as the Chinook Heaters, using heavy gauge copper fin tubes. As compared with Chinook it is much lighter and occupies less space.

Bayley Plexfin Unit Heaters:

This unit incorporates Chinookfin radiation and Plexiform or Aeroplex fans. The fan assembly including top plate and motor is removable as a unit for maintenance and inspection. The heating element is a removable unit. Casing all welded extra heavy gauge. This is an exceptionally high grade unit at a moderate price.



Buffalo Forge Company

450 Broadway, Buffalo, N. Y.

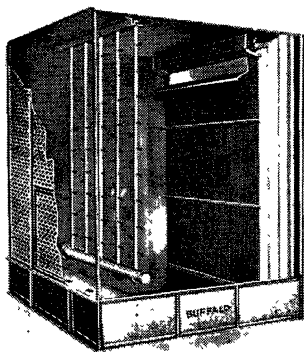
Branch Offices

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MINNEAPOLIS, MINN. 2102 Foshay Tower
NASHVILLE, TENN.—Southern Sales Co. 117 Fifth Ave., North
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SEATTLE, WASH. 500 First Ave., South
TOLEDO, OHIO 1922 Linwood Ave
WASHINGTON, D. C.—640 Woodward Bldg.,
15th and H Sts., N.W.
WILKES-BARRE, PA.—Power Engineering Co.,
517 Brooks Bldg

PRODUCTS: Heating and Ventilating Equipment including: Unit Heaters, Multiblade Fans, Pipe Coil Heaters, Buffalo Air Washers, Buffalo Unit Air Washers, Buffalo Unit Coolers, Drying Equipment, Mechanical Draft Fans, Air Preheaters, Exhaust Fans, Blowers, Dust Collectors, Disc Fans, Spray Nozzles.

Buffalo Air Washers

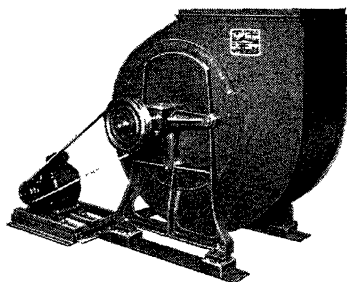


Buffalo Air Washers and Humidifiers are built for the most efficient washing, purifying and tempering of air under varying atmospheric conditions. Designed and constructed for low cost installation and maintenance. Careful attention to structural details insures long service-ability with a minimum of attention. Several types and models to meet specific plant requirements.

Fans for Every Ventilating Need

Buffalo Fans represent over 60 years of specialization in the design and construction of fans for practically every ventilating and air-handling application from small kitchen fans to rugged fans for boiler draft. For complete information state the type of fan you are interested in and a catalog will be sent.

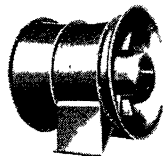
Buffalo Limit-Load Fans



Buffalo Limit-Load Fans for ventilating embody several improvements to deliver stepped-up efficiency under practical conditions. Durable built for years of service. Dynamically balanced. Quiet, economical to operate. Non-overloading characteristic prevents motor from overloading and burning out, regardless of fan load.

Buf-flow Axial Flow Fans

This specially designed high pressure fan—with directional guide vanes—propels the air stream in a true axial direction. Energy losses, are reduced to a minimum with a resulting increase in fan efficiency and marked power savings. What's more, this fan cannot overload and burn out the motor.



(See also Page 1072)

Champion Blower & Forge Co.

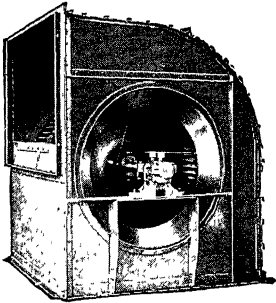
Manufacturers and Engineers

Plant and Offices: **Lancaster, Pa.**

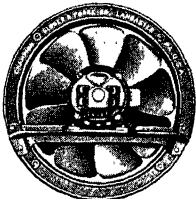
Address Correspondence to Div. 9

**Manufacturers of Blowers, Ventilating Fans and Exhaust
Fans for Air and Material; and Blast Gates**

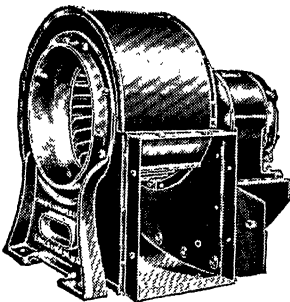
Representatives in Principal Cities



Type S Forward curve ventilating fans, single and double width, as well as direct motor drive.



Super Ventilating fans, direct motor drive up to 36 in. diameter. Motor belt drive up to 48 in. size.



Type BC Backward curve ventilating and exhaust fans, single and double width; belt driven and direct connected electric.

Ventilating Fans—For air conditioning systems and mechanical draft. Manufactured in the forward curved type for slow speed, and extremely quiet operation; also in the backward curved type with its flat horsepower curve characteristics and higher speeds suitable in the smaller sizes for direct connecting to synchronous speed motors. Ventilating Blowers manufactured in sizes up to 60 in. diameter wheel, in single and double width. Belt driven blowers equipped with either ball or high-grade babbit bearing. Direct motor drive can be equipped with any type or characteristic motor desired, in any arrangement.

Disc Fans—Super Ventilating Fans made in direct connected type up to 36 in. diameter, totally enclosed, ball thrust type motors. Slow speed motor belt driven type manufactured in sizes up to 48 in. for attic exhaust work and wherever large volumes of air are to be moved against low static pressures. All disc fans are quiet in operation. Decibel ratings on all fans are available.

Forced Draft Fans—All sizes for use on the smallest to largest boilers. Fans can be furnished with inlet or outlet adjustable louvers for controlling air volume.

Blast Wheels—We are well equipped to manufacture single and double width blast wheels in forward or backward curve type for oil burner and stoker manufacturers, as well as manufacturers of air conditioning units and other ventilating equipment.

Vibration Dampener Sub-Bases—For blower and ventilating equipment. Made with heavy channel iron and rubber vibration eliminator pads to suit size and weight of fan or blower.

Special Fan Equipment—We are in position to engineer and build fans, blowers, or exhausting equipment to meet customers' special needs. A card addressed to Div. 9 will bring you complete catalog data or information on any particular problem confronting you.

DeBothezat Ventilating Equipment Division

American Machine and Metals, Inc.

(Main Office and Factory)

902 DeBothezat St., East Moline, Illinois

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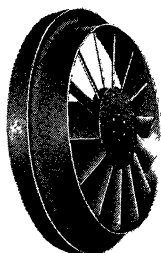
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AXIAL FLOW
PRESSURE FANS

NON-OVERLOADING POWER CHARACTERISTICS CERTIFIED RATINGS—GUARANTEED PERFORMANCE

Axial Flow Ventilating Sets



*Ventilating Fan
Axial Flow*

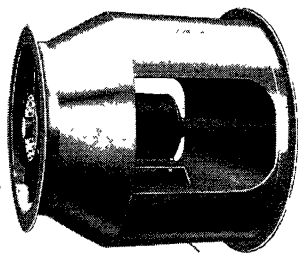
A complete series of volume and pressure axial-flow fans of high mechanical and static efficiencies with a non-overloading power characteristic. These fans offer savings in space, weight and power. Axial-Flow Ventilating Sets are available in a wide range of capacities in sizes 8 in. through 10 ft in diameter, and may be had arranged for direct motor drive or belt drive.

Bifurcators

Designed for handling corrosive or high temperature vapors with direct motor driven fan. Motor is located in chamber open to atmosphere but isolated from gases handled by fan. Installed as integral part of duct system, in any position.

Multi-Stage Impeller Blowers

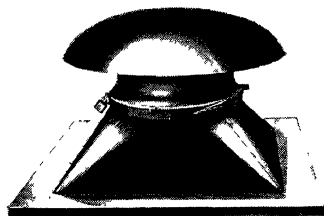
Units can be furnished in 2, 4, 6 or 8 stages. Direct motor or belt driven, producing high capacities and static pressures, with non-overloading power characteristics.



Bifurcator

"Power-Flow" Roof Ventilators

Designed to provide positive ventilation at all times regardless of temperature, humidity and wind velocity. Guaranteed performance ratings. Equipped with high-efficiency Axial-Flow Pressure Fan, these "Power-Flow" Roof Ventilators possess the greatest air moving capacity per horse power! Low fan tip speeds permit unusual quietness of operation. Work efficiently against resistance of duct systems. Have non-overloading power characteristic available in a wide range of sizes, speeds, and for all standard electric current. Hinged top gives easy access to motor, fan and shutter.



"Power-Flow" Roof Ventilator

The above is only a partial list of the ventilating units DeBothezat builds. Our engineers will be glad to give you expert assistance in your ventilating problems—offering you a solution in space, weight and power saving equipment. Catalog on all products sent on request.

The Lau Blower Company

2007 Home Avenue, Dayton, Ohio

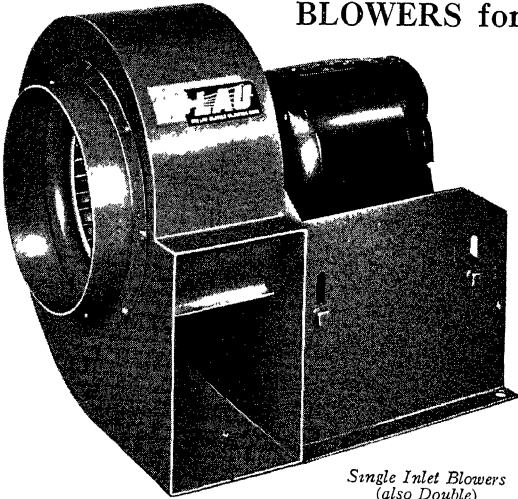
Manufacturers of Air Handling Equipment

LAU Blowers • Fans • Wheels • Pillow Blocks



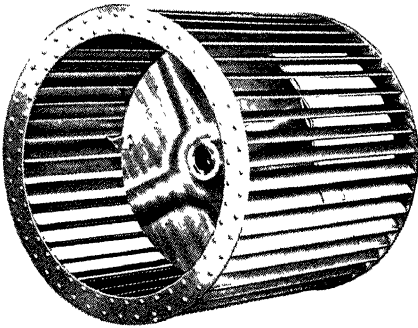
BLOWERS for Various

Applications in the War Effort



*Single Inlet Blowers
(also Double)*

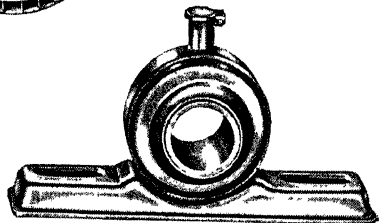
—for ventilation in ships; ventilation applications in camps; ventilation of enclosed armor equipment; ventilation of portable, temporary, and permanent laboratories; for airplane heaters and coolers; for portable and stationary refrigeration units; forced draft boiler units; heating and drying units; special workrooms; in fact for any place where it is necessary or desirable to bring air to or take air away from any given point.



*Blower Wheels Large and Small
Various Diameters—Various Widths*



*Self-Aligning Pillow Blocks
(BELOW)*



Variable and Constant Speed Pulleys (BELOW)

Catalogs, performance data, specifications, and prices available on above and other air handling equipment. Inquiries solicited for any application. Our engineers will help you. Write us regarding your requirements.





GENERAL OFFICES
32nd STREET & SHIELDS AVENUE • CHICAGO
FACTORIES at LAPOPE, IND. and CHICAGO, ILL.

Experienced Air Engineers
Representatives in Principal Cities



Products . . . for all industrial processes, ventilation and heating. Specify them for every industrial, commercial and institutional requirement. Check these nine classifications which give thumb nail specifications:

- **CENTRIFUGAL FANS AND BLOWERS**
Type ME Housed Centrifugal Wheels—Quiet Operating, Slow Speed Type and/or High Speed Wheels with Non-overloading Horsepower Characteristics. Range of Standard Wheel Sizes 15 in. to 80 in. Wheel Diameter. Sizes 15 inch to 80 inch Wheel Diameter.
- **JUNIOR CENTRIFUGAL BLOWERS**
Type ME Junior Fans, direct connected Motor Driven. Range of Sizes 6 inch to 12 inch Wheel Diameter.
- **DISC TYPE (or PROPELLER) PANEL FANS**
Comet EXHAUSTAIR Ventilating Fans, Automatic Shutters, Power Roof Ventilators, direct connected Motor Driven. Size 10 inch to 30 inch Wheel Diameter. Heavy Duty Type, Pulley Driven, GIANT Disc Type Fans, Regular Sizes 36 inch to 108 inch Wheel Diameter with Round Body Frames.
- **INDUSTRIAL UNIT HEATERS**
Disc or Propeller Fan, Ceiling Suspension Type, NYBCo COMET Unit Heaters with Molybdenum Alloy Corrosion-Proof and Freeze-Proof, Extra Heavy Welded, Longlife Ferrous Heating Element. Suitable for low or high-pressure (unlimited) Steam Pressures. Capacities 24,000 to 300,000 BTU's per Hour. Excel AIR-FLOW Centrifugal Type Factory Unit Heaters. Blower-Type Unit Heaters with Encased Centrifugal Fans with NYBCo Molybdenum Alloy Welded Steel Heating Element (either Blow-through or Draw-through Type). Floor Type, Side-wall or Ceiling Suspension. Capacities 169,000 to 1,000,000 BTU's per Hour.
- **MECHANOVENT UNIT VENTILATORS**
CLASSROOM Unit Ventilators, highly refined in design and appearance. A De-Luxe Product in every sense. Sueded for fully Automatic Temperature and Humidity Regulation. Capacities 750 CFM to 1560 CFM for Classroom Duty.

- **MECHANOVENT UNIT VENTILATORS (Continued)**
AUDITORIUM Unit Ventilators, Fully Encased Centrifugal Type Units, with or without Fresh Air and/or Recirculation Damper Assemblies, for use in Auditoriums or other places of large public gatherings. Capacities 2,000 CFM to 10,000 CFM.
- **AIR WASHERS**
A completely engineered line of PEERLESS Air Washers, Air Cleansing, Air-Conditioning and Cooling. Complete with Single- and Double-bank Atomizing Spray Systems, Marine Type Doors, Eliminators, Entering and Back-spray Louvers, Water Strainers, Pumps and Motors, and with or without Humidity Flooding Provisions. Sizes and Capacities ranging from 3,600 CFM to 76,000 CFM.
- **HOT BLAST HEATING SURFACE**
NYBCo "STEELFIN" Longlife High Pressure Molybdenum Alloy Steel, All Welded, Extra Heavy Duty, Homogeneous Fin-and-Oval-Tube Hot-Blast Heating Surface. Hot-dip Overall Metallic Coating, Including Headers. A Super-quality Product—proof against faults common to Surfaces constructed of Non-ferrous and Cast Iron Materials. An Engineered Product of Sizes and Capacities for Steam Pressures (or Hot Water Equivalents) from 2 lbs to 150 lbs. duty, High Temperature or Low Temperature Fin Spacings, and a Range of Air Velocities from 400 to 1000 Ft. per Min.
- **VENTO, AEROFIN, and OTHER HEATING AND COOLING SURFACES**
The various types and makes of Heat Transfer or Heat Exchange Surface, as regularly sold through the outlets of manufacturers of Fan-system Apparatus. These types of Surface are offered in various combinations and sizes, together with full and complete engineering recommendations.
- **MISCELLANEOUS**
Dust and Shavings Exhausters and Material Conveyor Blowers (Centrifugal Fans with Special Housings and Wheels); Engines, Motors, and V-Belt and Other Drives; Air Filters—Automatic and Cartridge or Renewable Types; Control Devices, including Pressurestats, Thermostats, Humidistats; Turbine Ventilators; Gas-fired Unit Heaters; Specialties; and Other Apparatus for use in conjunction with Complete Blower Systems. Complete data and descriptive matter furnished on specific request.



Certified Ratings

Write for Catalogues

Full Catalog Matter, Descriptive Bulletins, Performance Tables, Engineering Data and Technical Presentation, Prices, and Complete Information with Illustrations will be furnished upon request of District Representative or by Home Office.



Since 1889

The Torrington Mfg. Co.

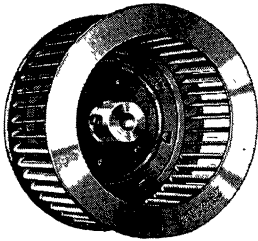
50 Franklin Street, Torrington, Conn.

Manufacturers of Blower Wheels and Propeller Type Fan Blades.

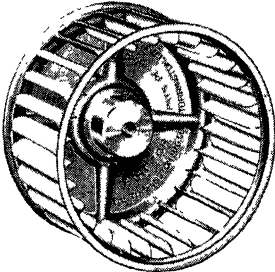
AIRISTOCRAT
Quiet Propeller Fan Blades

AIROTOR
Blower Wheels

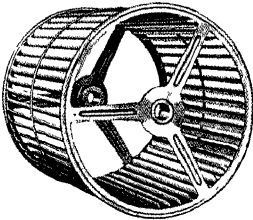
AUTOCRAT
Fan Blades



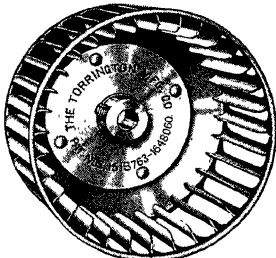
Single Inlet Aluminum Blower Wheel



Airotor Blower Wheel—Single Width—Single Inlet
Patents 2,231,062; 2,231,063; Des 126,043;
2,272,695



Airotor Blower Wheel—Double Width—Double Inlet
Spider End Plates
Patents 2,231,062, 2,231,063, 2,272,695



Cup Type Blower Wheel. Pats. 1,513,763; 1,648,060

Torrington Aluminum Blower Wheels produce the smooth, quiet performance which is essential in modern heating and air conditioning units because the unique patented construction breaks up resonance and minimizes noise. Made of aluminum, they resist corrosion and their light weight facilitates quick starting—saves power. Every wheel is statically balanced.

Bulletin lists 34 sizes of single inlet single width and 34 sizes of double inlet double width wheels, including guaranteed capacities for each. Also gives detailed dimensions for all wheels and table of dimensions for housing scrolls. We do not manufacture housings.

Sizes 3 in. to 15 in. diameter in all standard widths.

Torrington Airotor Blower Wheels are light, sturdy and inexpensive—incorporate new principles of design and construction, which insure rigidity and concentricity. **Single Width—Single Inlet** wheel is of simple four-piece construction. **No rivets or welds are used**; concentric rib serving as backing for blade strip is formed at same time as hub socket, insuring trueness of wheel. Rigid radial ribs prevent deflection by thrust. Three thicknesses of metal in rims make for maximum strength. Manufactured in both aluminum and steel in $3\frac{3}{8}$ in., $4\frac{1}{2}$ in., 5 in., 6 in., $7\frac{1}{2}$ in., 9 in. and $10\frac{1}{2}$ in. diameters. Same sizes available in DA type double width, double inlet wheels.

Torrington Airotor Blower Wheel—Double Width—Double Inlet—Spider End Plates, has blades punched and formed in a single strip, rigidly held by flanged single piece end rings. Hubs are rigidly mounted by peening. Wheels of $3\frac{3}{8}$ in., $10\frac{1}{2}$ in., 12 in. and 16 in. diameter are available at present; $4\frac{1}{2}$ in., 5 in., 6 in., $7\frac{1}{2}$ in., 9 in. and 20 in. sizes are being developed.

Torrington Cup Type Wheels—Used for automobile heaters, gun type oil burners, windshield defrosters, small hair dryers, hand dryers, ice box and refrigerator circulators, window ventilators, exhausters, etc. Made for either clockwise or counter clockwise rotation, of steel, in sizes: 3 in. to 9 in. inclusive

AIRISTOCRAT Quiet Propeller Fan Blades are widely recognized for their all-around excellent performance. The unique, patented construction embodies entirely new principles in the art of fan design—produces a blade unsurpassed for quiet operation, rugged construction and attractive appearance. Every **Airistocrat** unit is carefully built and the blades are hand gauged for correct contour and alignment. Statically balanced, these blades deliver full air volume with a minimum of noise. Aluminum alloy blades and steel spiders are standard except where otherwise noted. Rotation is clockwise only (facing air delivery side).

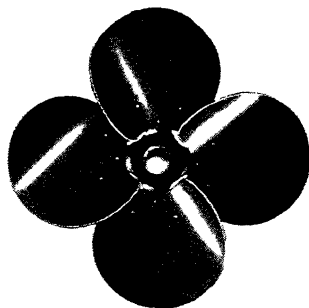
Available in the following finishes: 1. Plain—no finish on blades, spiders or hubs. 2. Blades with no finish; spider and hub with cadmium plate or black lacquer. 3. All black lacquered, with or without center button. 4. Buff and lacquered blades, black lacquered spider and hub, with or without center button. Catalog gives detailed dimensions and guaranteed performance curves recorded under *NEMA* and *NAFM* code tests at various speeds for each of the **Airistocrat** models described below.

“Standard” Series—Has blades mounted on a steel spider. Sturdy, attractive steel or aluminum blades which have withstood extreme laboratory breakdown tests. Sizes 8 in., 10 in., 12 in., 14 in., 16 in., 18 in. and 20 in. diameters in a variety of pitches to meet every need.

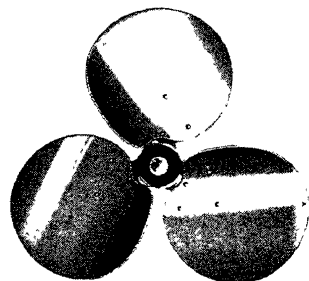
Three Blade “Y” Series—The design of this blade is the result of two years of laboratory experiment to produce a better air circulator blade. At recommended speed these blades produce a high velocity air stream effecting deep penetration with unusual quietness. Sizes 10, 12, 14, 16, 18, 20, 24 in. and 30 in. diameters, steel or aluminum blades

Pressure “P” Series—Similar in construction to “Standard” Series but with blades especially designed for higher pressures. Sizes 10 in., 12 in., 14 in., 16 in. and 18 in. diameters.

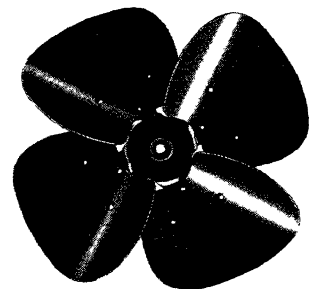
Pressure “U” Series—Two and four blade models of steel designed for pressure operation. Sizes 20 in., 22 in., 24 in., 26 in., 28 in. and 30 in. diameters. 24 in. and 30 in. sizes suitable for attic fans. Bulletin gives complete specifications and ratings.



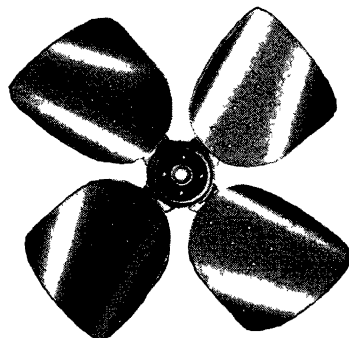
*Airistocrat “Standard” Series
Pats 2,072,822 and 2,021,707*



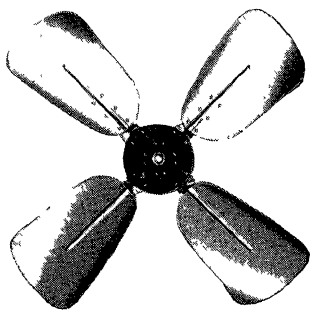
3-Blade Airistocrat “Y” Series



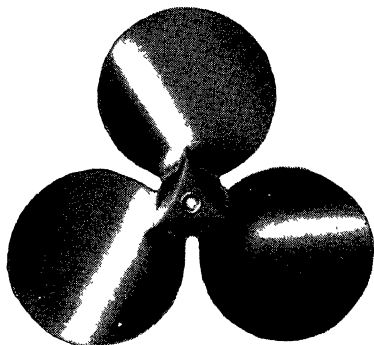
4-Blade Airistocrat Pressure Fan “P” Series



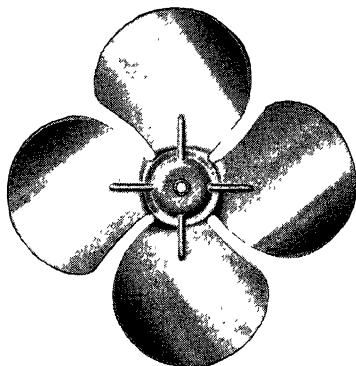
*4-Blade Airistocrat Pressure Fan “U” Series
(also made in two blade model)*



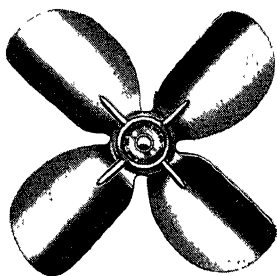
4-Blade Airistocrat Attic Fan "A" Series
(also made in 2 and 3 blade models)



Airistocrat
3-Blade "One Piece" Series



4-Blade "One Piece" Airistocrat Fan



Autocrat Fan Blade

AIRISTOCRAT "A" Series Attic Fan
Blades are the result of extensive study and experiment to produce blades having extraordinary efficiency, to sell at lower than average prices. **LOW COST** is possible because tools are interchangeable for production of either 2, 3 or 4 blade models in any diameters from 24 in. to 48 in. inclusive (sizes 24 in., 30 in., 36 in., 42 in. and 48 in. are standard). Construction approved only after severe breakdown tests. The extremely high **EFFICIENCY** is attained by the application of correct principles of design. Blades, spiders and hubs are of steel. Available in the following finishes: 1. Plain. 2. Aluminum lacquered blades, black lacquered spider and hub. 3. All one color lacquer. Bulletin gives detailed dimensions and specifications; also performance data.

3-Blade "One-Piece" Series Propeller Fan—An attractive, inexpensive one-piece blade incorporating the **Airistocrat** features for quiet operation. Available in both steel and aluminum. Sizes 8 in. and 10 in. diameters.

4-Blade "One-Piece" Series Propeller Fan—An exceptionally rigid model blanked from one piece of metal with four wide blades. Quieter than narrow blade types. Made in both steel and aluminum. Clockwise rotation only (viewing air delivery side). Sizes 8 in., 9 in., 10 in., 12 in., and 16 in. diameters. Available in the following finishes: 1. Plain. 2. Lacquered. 3. Nickel or cadmium plated (steel only).

AUTOCRAT Fan Blades—For auto heaters, windshield defrosters, electric heaters, etc. Have been standard ever since these devices were first marketed. Made in sizes 3 in., 4 in., 4½ in., 5 in., 5¼ in., 5½ in., 6 in., 6¼ in., 6½ in., all four blades, also 7 in. 5-blade, in one piece of cold rolled steel or aluminum with brass hubs, complete with set screw. ¼ in. bore is standard. Either clockwise or counter clockwise rotation (expressed when looking at air delivery side of fan). White nickel is standard finish for steel blades. Bulletin gives complete specifications and ratings.

B. F. STURTEVANT COMPANY

Air Conditioning, Heating, Ventilating, Dust Control and Fume Removal Equipment, Vacuum Cleaners, Dryers, Compressors, Motors, Turbines, Mechanical Draft Equipment

Main Office and Works

Hyde Park, Boston, Mass.

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PLANTS Located at HYDE PARK, BOSTON, MASS.; LASALLE, ILL.; CAMDEN, N. J.; BERKELEY, CALIF., and GALT, ONT.

B. F. STURTEVANT COMPANY OF CANADA, LTD., GALT, ONT., Sales Offices in Toronto and Montreal, and representatives in principal Canadian Cities.

COOLING & AIR CONDITIONING DIV. of B. F. Sturtevant Co. is Organized to Engineer and Install Complete Industrial Air Conditioning Systems.

OFFICES: Atlanta, Ga.; Hyde Park, Boston, Mass.; Camden, N. J.; Cleveland, Ohio; Greensboro, N. C.; Los Angeles, Calif.; New York, N. Y.

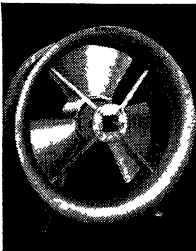
HOW STURTEVANT ENGINEERING SERVICE CAN HELP YOU

As the world's largest concern engaged in the manufacture of Air Handling Equipment, backed by more than 80 years' experience, B. F. STURTEVANT COMPANY is exceptionally qualified to help you attain the most efficient and economical solution of any air handling problem. Skilled Sturtevant engineering experts, located in many leading cities are prepared to render the following 5-point service: (1) Analyze your problem. (2) Recommend the solution. (3) Specify the equipment. (4) Supervise the installation. (5) Check the operation.

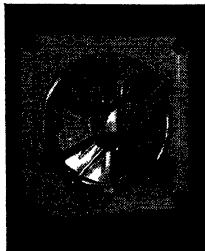
Whether requirements call for a single unit of apparatus or a complete engineered system, Sturtevant engineers can recommend the solution best suited to fulfill your individual needs. Do not hesitate to call the Sturtevant representative nearest you for assistance. Needless to say, no obligation is incurred.

As a preliminary aid, we list on the following two pages the major types of equipment manufactured by us, together with their general applications and the reference numbers of catalogs available.

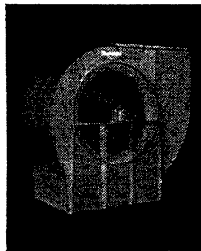
ILLUSTRATIONS OF SOME OF THE MAJOR LINES OF STURTEVANT EQUIPMENT



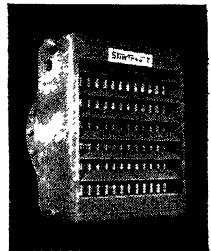
Axiflo Fan (25)



*Propeller Fan Design
7 (29)*



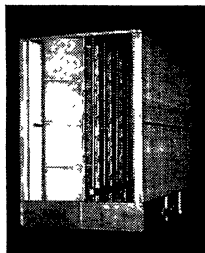
*Multivane Fan Design
6 (30)*



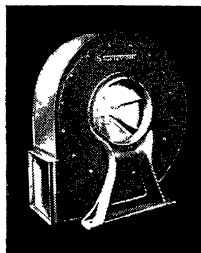
Speed Heater (40)



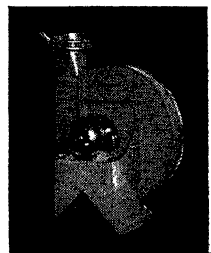
*Centrifugal Compressor
Design 14 (14)*



*Filterwasher Showing
Filter Spray Nozzles (6)*



*Planovane Fan Design
3 (32)*



*Centrifugal Compressor
Design 9 (12)*

STURTEVANT EQUIPMENT INDEX AND OTHER ILLUSTRATIONS ON NEXT PAGE

B. F. STURTEVANT COMPANY

TABULAR VIEW OF STURTEVANT EQUIPMENT AND APPLICATIONS

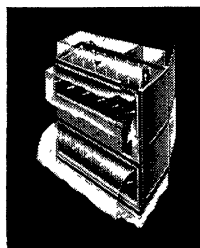
This table shows at a glance types of equipment manufactured by B. F. Sturtevant Company and their general application, together with catalog numbers on specific equipment. The numbers shown under "General Application," in the left

column refer to the Index of Products. If no catalog number is given, write to B. F. STURTEVANT COMPANY, main office, or to the nearest branch office, stating specific requirements, and complete information will be sent immediately.

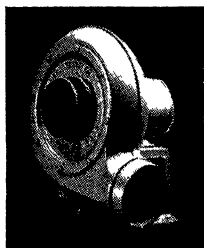
General Catalog No. 463 gives brief descriptions, Capacities, etc. of all Sturtevant Products

GENERAL APPLICATIONS	STURTEVANT EQUIPMENT INDEX	TRADE NAME OR DESIGN NO.	CAT. NO.
AIR CONDITIONING	1 Air Blenders	"Air Blenders"	
2 Air Conditioning Apparatus	Sturtevant	425-2	
3 Air Conditioning Systems, Industrial	Sturtevant		
4 Air Conditioning, Railway	"Railvane"	401-1	
5 Air Heaters	Sturtevant	450	
6 Air Washers	"Filterwasher"	453	
7 Blowers, Ventilating	"Rexvane Vent Sets"	400-9	
8 Blowers, Small Portable	"Big Midget"	F1266	
9 Blowers, Pressure	"Steel Pressure"	297-1	
10 Collecting and Conveying Systems	Sturtevant	291-2A	
	Compressors, Centrifugal		
11 —vols. 35-75 c f m., 12-20 oz. press.	Design 7	408-2	
12 —vols. to 5,500 c f m. 1/2-3 lbs. press.	Design 9	386-1	
13 —vols. 35-650 c f m., press. to 5 lbs.	Design 1	431	
14 —vols. to 60,000 c.f.m. press. to 5 lbs.	Design 14	458	
15 Cooling Coils (Extended Surface) Water and Direct Expansion	Sturtevant		
16 Drying Systems	Sturtevant	461	
17 Dry Kilns, Lumber	Sturtevant		
18 Dust Collectors	Sturtevant		
19 Economizers, Cast Iron	Sturtevant	405	
20 Engines, Vertical Steam	Sturtevant		
21 Engine Generator Sets	Sturtevant		
22 Exhausters (Material Handling)	"Planovane," Des 3	410-3	
23 Exhausters, Slasher (Textile)	Sturtevant	432-1	
24 Fans—Attic Ventilating	"Atticvane"	400-9	
25 —Axial Flow, Pressure Type	"Axiflo"	444-1	
26 —Engine Cooling	Engine Cooler	418-5	

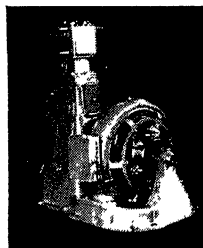
CONTINUED ON NEXT PAGE



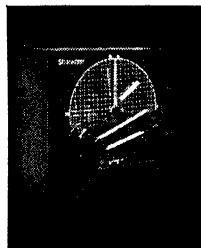
Air Heater (5)



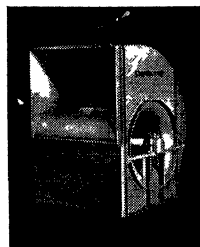
Steel Pressure Blower (9)



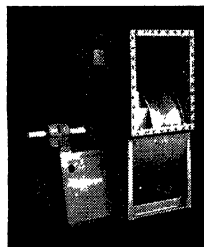
Engine Generator Set (21)



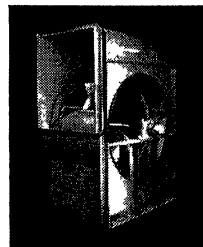
Engine Cooler for Gas, Diesel Engines, etc. (26)



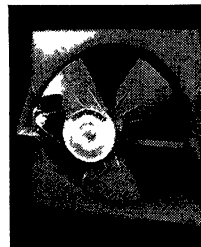
Silentvane Fan Design 8 (33)



Silentvane Fan Design 7 (32)



Rexvane Fan Design 3 (31)

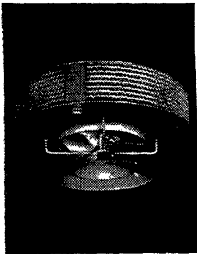


Atticvane Fan (24)

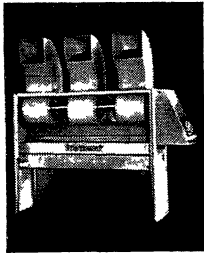
B. F. STURTEVANT COMPANY

B. F. STURTEVANT EQUIPMENT—Continued

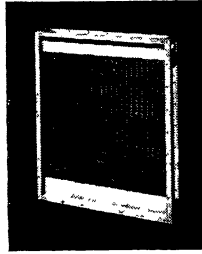
GENERAL APPLICATIONS	STURTEVANT EQUIPMENT INDEX	TRADE NAME OR DESIGN NO.	CAT. NO.
MECHANICAL DRAFT	27 —Fume and Dust Removal, Materials Handling	"Planovane," Des. 3	410-3
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	29 —Propeller, Motor Driven	"Multivane," Des. 6	271-4
	30 —Low Speed, General Purpose	"Rexvane," Des. 3	414-4
	31 —Medium Speed, General Purpose	"Silentvane," Des. 7	449
	32 —High Speed, Industrial	"Silentvane," Des. 8	437
	33 —High Speed, Heating and Ventilating		
PNEUMATIC CONVEYING	34 —Mechanical Draft, Duplex type (Combined Forced and Induced)	Duplex	436
9, 10, 11, 12, 13, 14, 22, 27, 44, 45	35 —Mechanical Draft, Low Speed, Induced Draft, Abrasion-resistant	S.P.I.D., Des. 2	447
	36 —Mechanical Draft, Medium Speed, Large Volume, Forced and Induced	M.V.M.D., Des. 6	409
	37 —Mechanical Draft, High Speed, Forced Draft	T.V.F.D., Des. 9	448
	38 —Mechanical Draft, High Speed, Induced Draft	T.V.I.D., Des. 2	445
PRIME MOVERS	39 —Theatre Ventilating	Theatre Fans	424-1
20, 45, 48	40 Heaters, Unit, Directional Flow Type for Wall and ceiling mounting	"Speed Heater"	396-9
	41 Heaters, Unit, Downblast Type, for ceiling mounting	"Downblast"	454
	42 Heaters, Unit, Large Capacity, for floor, wall, ceiling mounting	"Multivane"	452
VACUUM CLEANING	43 Heating Coils (Extended surface)	Sturtevant	462
12, 13, 18, 45, 52, 53, 54, 55, 56	44 Melt-Recovery Units (Welding)	Sturtevant	438-1
	45 Motors, Electric	Sturtevant	433-1
	46 Roof Ventilators	"Roofvane"	422
	47 Surface Dehumidifiers		
	48 Turbines, Steam, Helical Flow Type	Sturtevant	426
	49 Unit Ventilators, Schoolroom Type	Sturtevant	377-1
	50 Unit Ventilators, Auditorium Type	Sturtevant	S377-1
	51 Ventilating Sets, Direct Connected Motor	"Rexvane," Vent Sets	406
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7, 24, 25, 26, 29, 30, 31, 33, 45, 46, 49, 50, 51	53 Vacuum Cleaners, Portable Furnace type	"Vortex"	397-2
	54 Vacuum Cleaning Systems, Commercial Buildings	Sturtevant	373-6
	55 Vacuum Cleaning Systems, Industrial	Sturtevant	397-2
	56 Vacuum Cleaner Attachments	Sturtevant	368-3
	57 Vane Control (Fan)	Sturtevant	387-1
		Sturtevant	446



Downblast Heater (41)



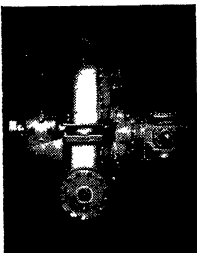
Multivane Heater (42)



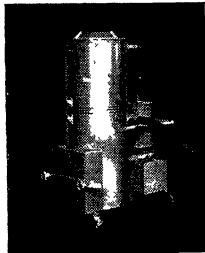
Extended Surface Heating Coil (43)



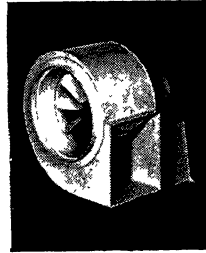
Sturtevant Electric Motor (45)



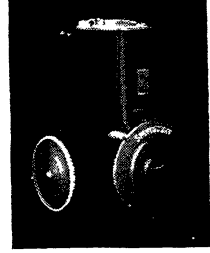
Sturtevant Steam Turbine Design 12 (48)



Melt Recovery Unit Portable Type (44)



Rexvane Vent Set (51)



Vortex Portable Vacuum Cleaner (52)

GENERAL ELECTRIC

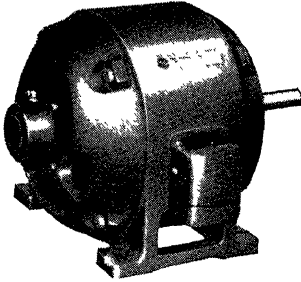
Schenectady, N. Y.

Sales Offices, Warehouses, Service Shops and Distributors in Principal Cities

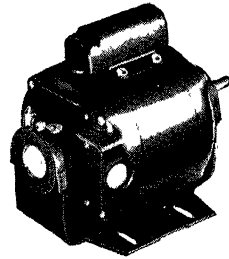
MOTORS FOR HEATING, VENTILATING, AND AIR CONDITIONING

General Electric offers a complete line of motors for compressors, fans, and pumps from which you can select easily the motors with electrical and mechanical characteristics best adapted to your equipment. Many of the most common applications are listed below. Complete information on other types of motors—vertical, enclosed, etc., with various electrical and mechanical modifications—can be obtained at a G-E office near you.

For additional information, ask for Motor Catalog GEA-623.



Tri-Clad induction motor,
Type K, polyphase*



*Fractional-horse-power capacitor
motor. Type KC*

SOME G-E MOTORS AND THEIR USES

Application	Speed	Type Winding	Type	Horsepower Range	Classification
Fans and Centrifugal Pumps	Constant or Adjustable	Shunt	B & CD	1/8-200	Direct-current
		Compound	B & CD	1/8-200	
Reciprocating Pumps and Compressors	Constant	High Torque Capacitor	KC & KCJ	1/4-3	Single-phase Alternating-current
Small Direct Connected Fans	Constant	Resistance Split-phase	KH	1/40-1/3	
		Shaded-pole	KSP		
	Constant or 3-speed	Low-torque Capacitor	KCP	1/50-1	
Belted Fans, Centrifugal Pumps	Constant	General-purpose	KC	1/4-3	
		Capacitor	KC	1/8-3	
		Repulsion-induction	SCR	5-10	
Reciprocating Pumps and Compressors	Constant or Multispeed	Squirrel-cage	K or KB	1/4-1000	Polyphase, Alternating-current
		High-starting-torque	K & KG	1/4-5 5-100	
Pumps, Compressors, Fans	Constant or Adjustable	Wound-rotor	M & MB	1/2-1000	
	Constant	Synchronous	TS	25-2000	

Types of Enclosures: Open—protected from falling objects or dripping liquids. Splashproof—where wetness is a factor. Totally enclosed—for complete protection. Explosion-proof—where explosive fumes or dusts are encountered.

For code wire, conduit products, wiring material, insulating materials, etc., address APPLIANCE & MERCHANDISE DEPARTMENT, BRIDGEPORT, CONN.

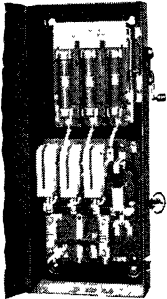
*Reg. U. S. Pat. Off.

GENERAL ELECTRIC

Schenectady, N. Y.

Sales Offices, Warehouses, Service Shops and Distributors in Principal Cities

CONTROL FOR HEATING, VENTILATING, AND AIR-CONDITIONING MOTORS

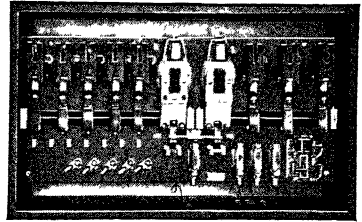


CR7008 combination a-c magnetic full-voltage starter. Provides short-circuit protection, as well as overload and under voltage protection

The General Electric line of standard control offers manual or automatic equipment for compressors, fans, or pumps driven by any type motor which you require, providing full protection for your motor, especially those listed on the preceding page.

For special applications, General Electric controllers can be designed to meet your exact requirements.

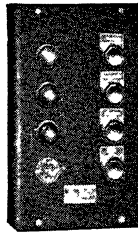
For additional information, ask for Control Catalog GEA-606.



CR7107 a-c magnetic controller for use with multi-speed squirrel-cage motors driving pumps, fans, or blowers



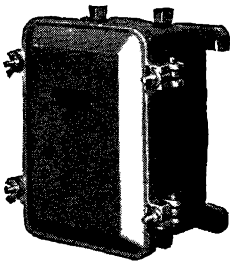
CR1062 manual full-voltage starter for small polyphase motors. Available in 2- or 3-pole forms, with temperature overload protection



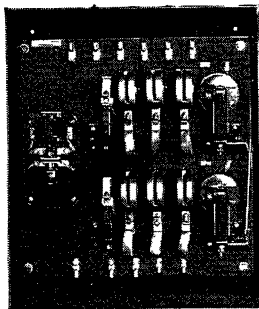
CR2940 indicating-light push-button station. Used with magnetic controllers to indicate speed of fan or blower



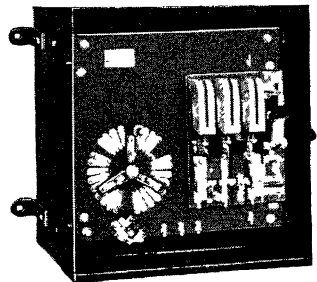
CR1061 manual starter for fractional-horsepower motors, a-c or d-c. Available in 1- or 2-pole forms, with temperature overload protection



CR7006-D51FS quiet magnetic switch. For full-voltage starting of squirrel-cage motors up to 5 hp, 220 volts. For applications where quiet operation is required, such as on fans or domestic air-conditioning systems



CR7896 throwover panels. To transfer motor or lighting load to emergency source of power if normal source fails. Re-transfers load when power returns to normal source



CR7764 a-c speed-regulating controller for wound-rotor induction motors. For controlling the speed of motors driving ventilating fans and blowers. Provides undervoltage and overload protection

A complete line of accessories, including pressure governors, pressure switches, float switches, electrically operated valves, and indicating Selsyns, is available.

This Company will gladly assist in the solution of any electrical problem in relation to heating and ventilation.

Wagner Electric Corporation

6403 Plymouth Avenue, Saint Louis, Mo., U. S. A.

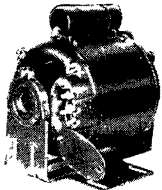
No matter what type of air-conditioning equipment is involved . . . whether large or small . . . regardless of the torque, speed or current requirements . . . you can choose a motor from the Wagner line that is correctly engineered for the job. Each motor illustrated below has special electrical and mechanical characteristics that make it the ideal motor for certain applications.

Type RA, Repulsion-Start-Induction Motors



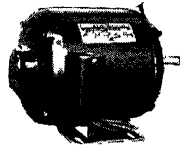
Type RA Repulsion-Start-Induction Motor—1/8 to 15-hp.

are single-phase brush-lifting motors having high starting-torque and low starting-current. The ideal motor for heavy-duty applications such as stokers, compressors, pumps, etc. Obtainable in various speeds, frequencies, and voltages; rigid or resilient mounted; 1/8 to 15-hp.



Type RK Capacitor-Start-Induction-Run Motor 1/8 to 3/4-hp.

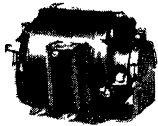
Type RK, Capacitor-Start - Induction - Run Motors are single-phase motors suitable for driving refrigerators, household air-conditioners, and other appliances. Drip-proof or totally-enclosed endplates; rigid or resilient mounted; 1/8 to 3/4-hp.



Type TB Split-Phase Unit-Heater Motor (Single-Phase) 1/20 to 1/4-hp.

Type TB, Split-Phase Unit - Heater Motors (Single-Phase) are totally-enclosed to prevent entrance of dust or moisture; ball-thrust bearings on front end to take care of end-thrusts imposed by fans; rubber mounted for ultra-quiet operation. 1/20 to 1/4-hp.

Type M, Shaded-Pole Fan Motors

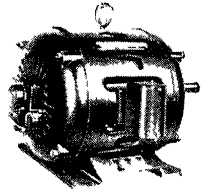


Type M Shaded-Pole Fan Motor 1/125, 1/80, 1/40 and 1/30-hp.

are single-phase induction motors of simple construction. Ideal for fan and blower drives in which the fans are mounted directly on the motor shaft. Totally-enclosed and open-type; rigid or resilient mounted; 1/125, 1/80, 1/40 and 1/30-hp.

Type RP, Polyphase Squirrel-Cage Motors

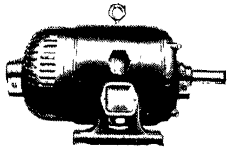
are made in 5 electrical types varied as to torque and current characteristics to take care of a wide variety of applications. 2- and 3-phase; 1/6 to 400-hp.



Type RP Polyphase Squirrel-Cage Motor—1/6 to 400-hp.

Type RT, Special Compressor Motors

were developed to meet the demand for a poly-phase motor with high starting-torque and very low starting-current. The RT motor is ideal for large compressors. The very low starting-current permits across-the-line starting. 2- and 3-phase; 40 to 100-hp.



Type RT Special Compressor Motor—40 to 100-hp

Type RS, Wound-Rotor (Slip-Ring) Polyphase Motors

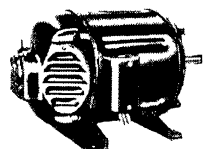
have adjustable varying speeds and combine the ability to start extremely heavy loads with good running characteristics. Smooth starting and adjustable varying speeds are effected by the use of external resistors. 1 to 250-hp.



Type RS Wound Rotor (Slip-Ring) Polyphase Motor—1 to 250-hp.

Type RD, Direct-Current Motors

may be used for direct-current service wherever repulsion-start-induction, split-phase, capacitor, or squirrel-cage motors would be used for alternating current service. Built in two types: Appliance Type up to 1 1/2-hp; Industrial Type, 1/20 to 3-hp.



Type RD Direct-Current Motor—1/20 to 3-hp.

M 43-1

A POSTCARD WILL BRING YOU MOTOR BULLETINS MU-182 AND MU-183

Anemostat Corporation of America

10 East 39th Street, New York City, N. Y.

THE ANEMOSTAT HIGH VELOCITY AIR DIFFUSER

THE ANEMOSTAT PRINCIPLE

ANEMOSTATS produce unparalleled results because they are the only air diffusers which operate on the following interdependent principles:

1. Air expansion within the device, which reduces velocity instantly.
2. True Aspiration, which causes room air equal to 30 to 35 per cent of the supply air to be drawn into the device where it is mixed with the supply air. The percentage of aspiration depends on the type of Anemostat used.
3. Creation of a multiplicity of air currents and counter-currents at low velocities, which causes slow but adequate secondary air motion.

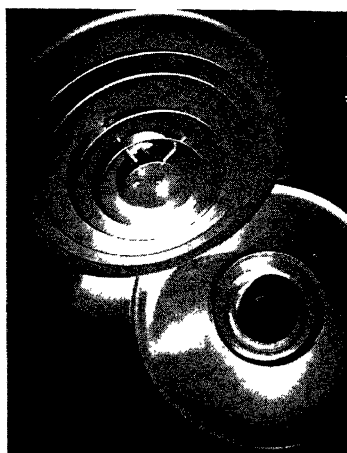
Type "A" Anemostat is a combination device for supplying air and either extracting it or returning it to the conditioner or heater. Designed to extract or return 75 cfm of room air for every 100 cfm of supply air. This percentage of extract or return may be increased or decreased by varying the extract velocities. It furthermore has an aspiration effect of 30 per cent. May be used with velocities up to 2500 fpm, and wherever both supply and return, or extract are required through the same unit. Should not be used with ceiling heights exceeding 16 ft.

Type "B" Anemostat is a diffusion device for supply air only. It has 35 per cent aspiration. May be used with velocities up to 4000 fpm and is suitable for industrial and commercial installations. Can be used on either exposed or concealed duct work.

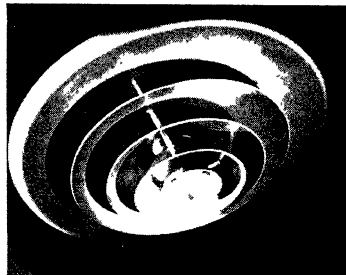
Type "C" Anemostat is a diffusion device for supply air only. It has 35 per cent aspiration. May be used with velocities up to 2500 fpm. Must be installed flush with ceiling and cannot be used on exposed duct work.

Type "W" Anemostat is a device for the diffusion of supply air from the wall. It has an aspiration effect of 35 per cent. Excessive air motion from the floor up to and including the breathing level is eliminated and the temperature differential, both horizontally and vertically between points in the occupied zone is reduced to a minimum. The effective diffusion covers an area within a radius of 180 deg. This result cannot be obtained by any other method which introduces air from a wall.

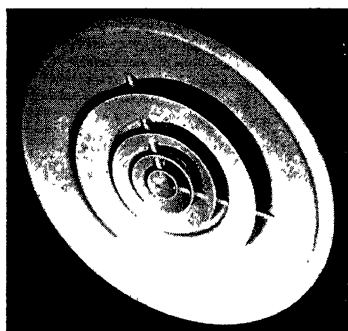
Type "HU-3" and "HU-4" Anemostats have been developed to obtain draftless, economical heat distribution from vertical discharge unit heaters, and uniform heat coverage of floor areas. Type "HU-3" and "HU-4" Anemostats may be combined with practically all sizes and types of Vertical Discharge Heaters on the market. A number of unit heater manufacturers now supply "HU" Anemostats as a part of their equipment. The complete and effective heat distribution produced by an Anemostat attached to a unit heater is a distinctive exclusive feature of the device



Anemostat Type "A"



Anemostat Type "B"



Anemostat Type "C"

"No Air Conditioning System is better than its Air Distribution"

Barber-Colman Company

Rockford, Illinois

ENGINEERED AIR DISTRIBUTION OUTLETS

Venturi-Flo

Venturi-Flo is a spun-steel overhead type air diffuser with flow characteristics similar to those of the well known fluid flow measuring device—the Venturi-Meter. The relationship between the neck area of the unit proper and the venturi throat area is so proportioned as to create a slight back pressure in the neck at all times, thereby automatically insuring uniform distribution around the entire periphery of the unit.

Three types of units are available, the recessed, the flush and the surface types. A wide range of sizes permits handling air volumes up to 15,000 cfm per unit.

Fittings for attaching any standard light fixtures to the outlets may be obtained for all three designs. They can also be furnished as combination supply and exhaust units, and with adjustable dampers.



Venturi-Flo—Recessed Type



Venturi-Flo—Flush Type



Venturi-Flo—Surface Type

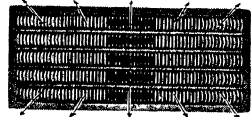
Uni-Flo

Uni-Flo grilles and registers are especially designed for air conditioning applications. They are engineered and prefabricated with directional flow aspirating fins for each individual installation. Proper air distribution is assured and the necessity of adjustment after installation obviated.

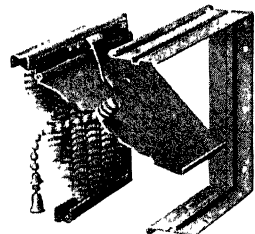
Uni-Flo grilles can be furnished in various shapes and sizes and for plane and curved surfaces.

Registers are similar in construction to grilles, but with the addition of spring loaded, positive closing chain or key operated dampers.

Electro plated finishes: Gunmetal, brushed bronze, plain zinc, buffed zinc, brushed zinc, satin copper. Also available in plain metal, grey prime coat, clear lacquer, and satin aluminum.



Uni-Flo Grille

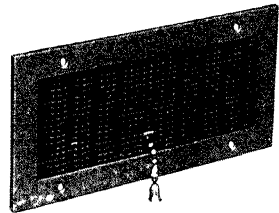


Uni-Flo Register

Uni-Fin

Uni-Fin grilles and registers are designed especially for residential warm air installations, and are available in standard sizes with prime coat or electroplated finishes.

(See also Page 998)

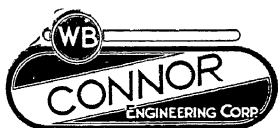


Uni-Fin Register

SEE OUR COMPLETE CATALOG IN SWEET'S

W. B. CONNOR ENGINEERING CORP.

114 East 32nd Street,
New York, N. Y.

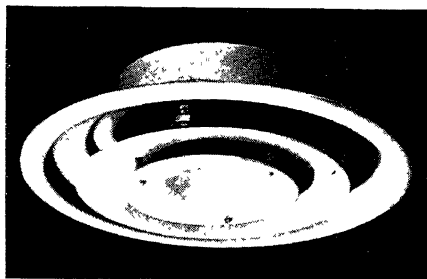


Offices
in All Principal Cities

Canadian Representative: D & D Air Conditioning Co., Montreal, Canada

Manufacturers of KNO-DRAFT Adjustable Ceiling Air Diffusers

KNO-DRAFT Type W-A-R Adjustable Air Diffusers insure efficient air distribution, adequate aspiration, noiseless and draftless diffusion, and uniform temperature throughout the occupied zone, regardless of season or ventilation requirements. Every KNO-DRAFT unit is easily and quickly adjustable for system balancing or seasonal regulation. During the heating season warm air can be forced downward to obtain proper mixture of room and supply air—a highly advantageous feature.



(Patents Pending)



(Patents Pending)

Model F KNO-DRAFT Diffuser—For Supply Air—attractive—light, yet sturdy—for high or low ceilings or attachment to exposed duct work. Anti-smudge rim prevents streaked ceilings. Sizes 2½ in. to 42 in. in neck diameter for capacities from 10 cfm to 20,000 cfm per unit.

Model SR KNO-DRAFT Diffuser—For Combination Supply and Return air to simplify duct work. Sizes 6 in. to 42 in. supply air neck diameter for supply capacities from 10 cfm to 9,000 cfm per unit, with central return air throat for 75 per cent of supply capacity.

The KNO-DRAFT Diffuser will effectively handle large volumes of air, pre-mixing room and supply air. It permits the use of higher duct velocities—resulting in smaller ducts and lower costs. Duct designs are simplified and fewer outlets are required. KNO-DRAFT Diffusers blend well with any architectural treatment—classical or modern. They are simple in construction, light in weight, and easily installed.

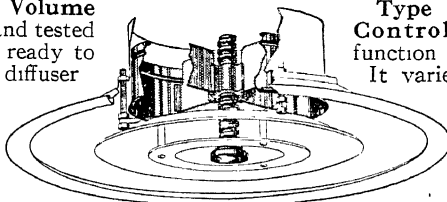
This New KNO-DRAFT Type W-A-R Diffuser has been so re-designed as to retain all of its superior features without wasting critical war materials. Now constructed of steel instead of aluminum, even this less critical material has been conserved, but without sacrificing durability, appearance, or efficiency.

THE TYPE DEE AIR VOLUME CONTROL is designed for application exclusively to KNO-DRAFT ADJUSTABLE CEILING AIR DIFFUSERS.

It is furnished already assembled within the diffuser and requires neither field assembly nor attachment to ducts, angle rings or other external appurtenances.

Type DEE Air Volume Control is adjusted and tested before shipment and ready to function when the diffuser is installed.

Its operation is entirely independent of the air direction adjustment which is part of all standard KNO-DRAFT Air Diffusers.



Type DEE Air Volume Control complements the function of the air diffuser.

It varies only the *quantity*, not the *characteristic* of the air distribution. With it, a series of diffusers may be balanced without affecting the air diffusion efficiency.

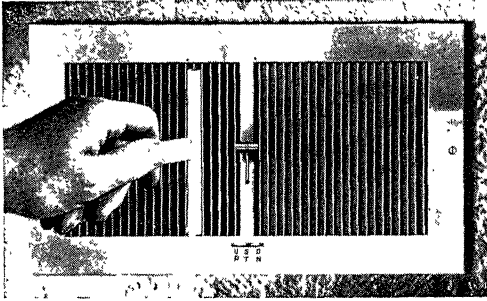
With KNO-DRAFT ADJUSTABLE CEILING AIR DIFFUSERS equipped with TYPE DEE AIR VOLUME CONTROL, the desired air pattern of any room or zone is AT YOUR FINGER TIP.

Hart & Cooley Manufacturing Co.

Established 1901

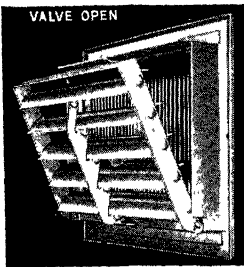
Air Conditioning Registers and Grilles - Warm Air Registers
Damper Regulators - Furnace Regulators - Pulleys - Chain
Holland, Mich.

NO. 75 DESIGN—FLEXIBLE FIN TYPE with TURNING BLADE VALVE to provide DOUBLE DEFLECTION. Also without Valve as Grille or Intake



CONTROL OF AIR FLOW IN TWO PLANES

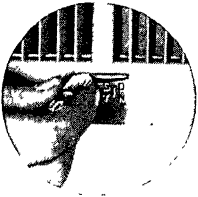
Instant Adjustment of Air Flow (Up, Straight or Down)



Is obtained by turning the regulator on the register face to the proper setting with a key furnished with each register. When the valve is opened, as shown at the left, the individual valve louvers automatically stop in position to provide the proper air flow—Up (Fig. 1) for cooling systems to avoid drafts; Straight (Fig. 2) for ventilating systems; Down (Fig. 3) for heating systems to prevent stratification. When the valve is closed, as shown at the left below, it completely stops the flow of air.

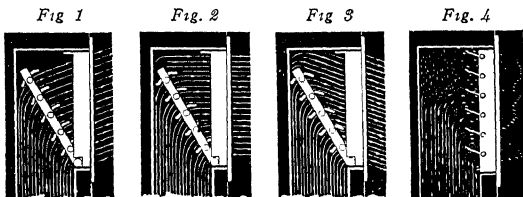
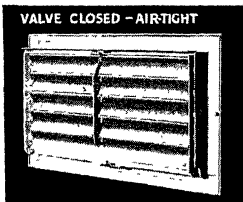
Air Flow Can be Quickly Adjusted Sideways

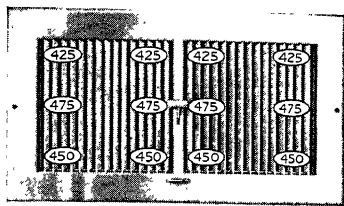
No. 75 Design has a flexible fin-type face. Each fin may be twisted individually with a wrench furnished with each register or grille to provide any desired sideway deflection of the air flow.



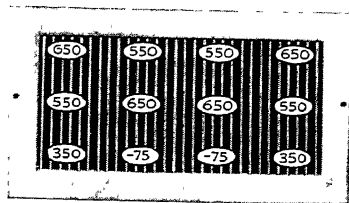
Greatly Reduced Turbulence and Resistance

Figs. 1, 2, and 3 show the air flow with No. 75 Design; Fig. 4, with the conventional register. Compare the turbulence in the stackhead of the latter with the smooth flow obtained with No. 75 Design. So efficient is No. 75 Design that there is actually less resistance with this register, using a standard stackhead, than if no register at all were used.





Velocities with No. 75 Design



Velocities with Conventional Register

EVEN DISTRIBUTION OF AIR OVER ENTIRE FACE

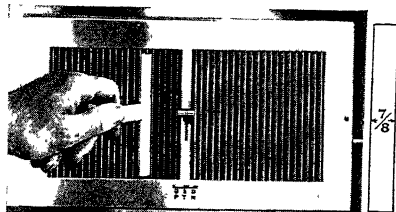
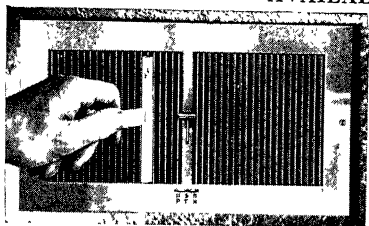
The turning blade valve distributes the air evenly with a uniform velocity over the entire face, as shown in Figs. 1, 2, and 3 on the preceding page. Note how the air rushes through the upper part of the face with a conventional register, as shown in Fig. 4. Since the entire face of No. 75 Design register is utilized for discharge of air, smaller and in some cases fewer registers can be used without causing excessive velocities.

Prevention of Streaked Ceilings—With either UP, STRAIGHT, OR DOWN deflections the air does not strike the ceiling immediately in front of the register, streaked ceilings are thus avoided.

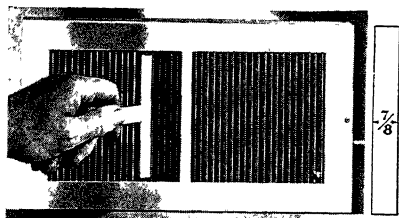
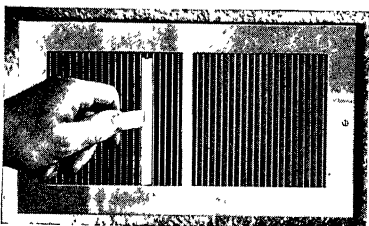
Excellent Concealment of Duct—The depth and close spacing of the vertical bars, combined with the valve, provide almost complete concealment of the duct, adding considerably to the pleasing appearance of the register face.

Special Settings—No. 75 Design functions equally well when located at the end of a horizontal duct or, by installing it upside down, when the air is delivered to it from above.

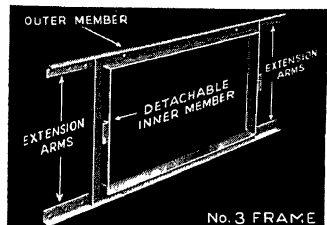
AVAILABLE IN FOUR TYPES



With Turning Blade Valve—No. 751 Register (Left) has Sponge Rubber Gasket and $\frac{3}{16}$ in. turndown. No. 754 Register (Right) is similar except has $\frac{7}{8}$ in. projection.



Without Valve—No. 750 Grille (Left) has Sponge Rubber Gasket and $\frac{3}{16}$ in. turndown. No. 757 Intake (Right) has $\frac{7}{8}$ in. projection.



FOUR TYPES OF INSTALLATION FRAMES AVAILABLE

No. 75 Design items can be used with or without installation frames. No. 3 Sidewall Stud Frame (illustrated), fastens directly to stud, forming a solid, streak-proof foundation for register. No. 8 Frame is similar for baseboard use. No. 5 Baseboard Stack Frame provides inexpensive, streak-proof installation. No. 2 Band Iron Frame provides for connecting register to stackhead.

CATALOG 42 showing the complete H & C line, available upon request.

Hendrick Manufacturing Company

Hendrick Perforated Metal Grilles

48 Dundaff Street, Carbondale, Pa.

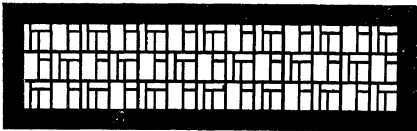
SALES OFFICES IN PRINCIPAL CITIES—CONSULT TELEPHONE DIRECTORY

PRODUCTS—Hendrick Perforated Metal Grilles; Mitco Open Steel Flooring;
Mitco Armorgrids; Mitco Shur-Site Treads.

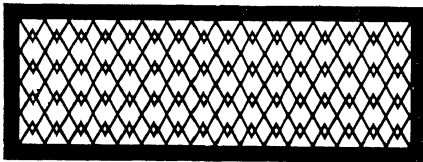
HENDRICK PERFORATED METAL GRILLES

To architects, engineers, contractors and others who buy or specify grilles, Hendrick offers literally hundreds of designs from which to select the pattern or patterns best suited to specific applications.

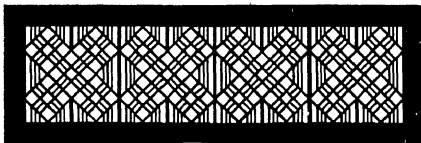
In addition to those popular designs which have been specified so consistently that they are today regarded as standard patterns, Hendrick offers a number of exclusive designs, many of them covered



Musak



M No. 9



La Crosse

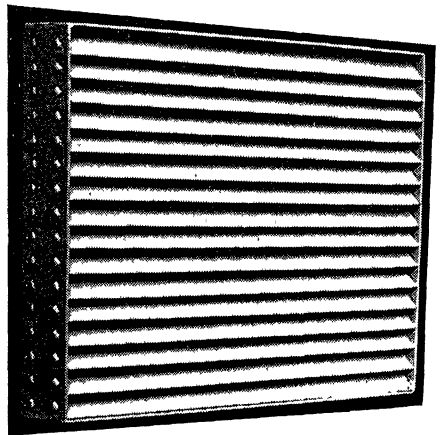
by design patents. Originally designed to meet specific requirements, these Hendrick patterns are available, without premium, to those who seek something that is distinctive as well as different.

All Hendrick Grilles are characterized by clean-cut perforations and fine finish. In addition, Hendrick grilles are put through a special flattening operation which insures easy installation.

HENDRICK FIXED LOUVRE GRILLE

One of the most popular grilles in the Hendrick line is a door grille, developed originally for hotels and hospitals but equally ideal for bathroom doors in residences.

Hendrick Fixed Louvre Grille is built up of a series of strips bent to a fixed angle and rigidly fastened into a band frame, a construction permitting free circulation of air but preventing vision through the grille from any angle. Easily installed in any door.



Hendrick Fixed Louvre Grille

Regularly furnished in No. 18 U. S. Gauge Steel; also obtainable in other commercially available metals.

Write on your letterhead for a copy of 194-page handbook, "Hendrick Grilles."

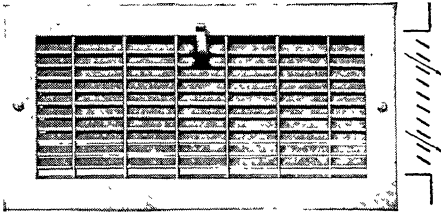
The Independent Register Co.

ESTABLISHED 1898

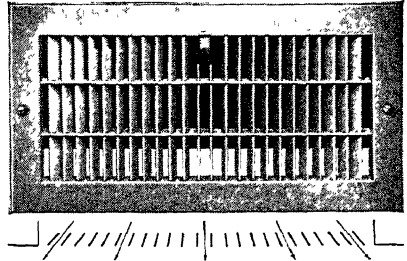
3747 East 93rd Street, Cleveland, Ohio

AIR CONDITIONING REGISTERS AND GRILLES

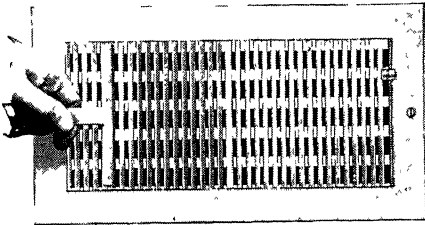
A Complete Line for Either Residential or Commercial Installations



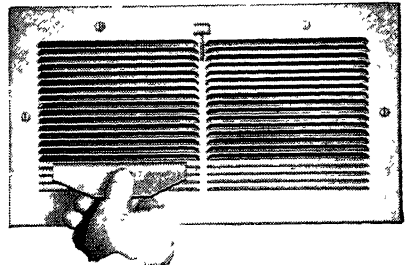
No. 311A "Fabrikated"—Grille Bars individually adjustable for upward or downward directed air flow.



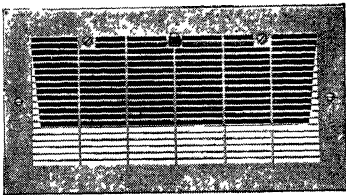
No. 321A "Fabrikated"—Grille bars individually adjustable for right or left directed air flow.



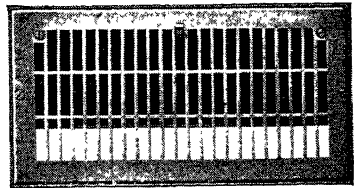
No. 238 Wrought Steel—4-way adjustable direction of air flow. Flexible vertical grille bars, multiple valves.



No. 139 Wrought Steel—Flexible horizontal grille bars, bendable for up, down or straight air flow. Single valves.



No. 136 Wrought Steel—Of fine appearance. Can be used to advantage on low priced installations. Single valves.



No. 137 Wrought Steel—A popular design, moderately priced. Single valves.

We manufacture many other types and styles
of Registers and Grilles; a complete line.

You should have the Independent Register Catalogues—Yours for the Asking.

REGISTER & GRILLE MFG. CO.

Incorporated

70 Berry Street, Brooklyn, N. Y.

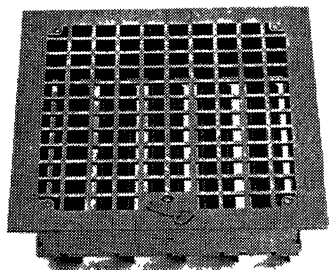
Headquarters for all types of Registers and Grilles

RESIDENTIAL AND COMMERCIAL

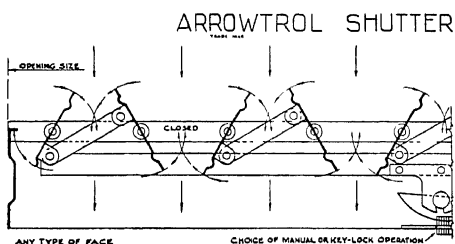
Register shutters of different types can be furnished with all types of Register Faces or Grilles.

All Register Shutters have our exclusive feature of brass collars inserted in the ends of the shutter to minimize rusting.

REGISTERS FOR VENTILATION

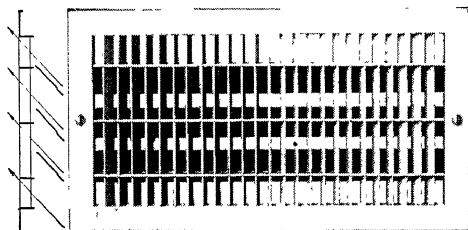


Style 3370 lock type Register allows directional flow of 135 deg either right and left or up and down Will open 45 deg beyond 90 deg



The Arrowtrol, line cut shown above, gives straight throw in connection with volume control

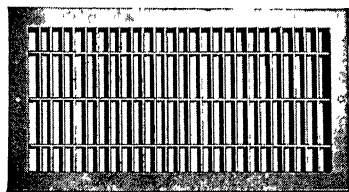
FOUR-WAY DEFLECTION TO AIR FLOWS



Style 3320 Grille and HMV deflecting vane

Front bars vertically adjustable, rear vanes horizontally adjustable; or Front bars horizontally adjustable, rear vanes vertically adjustable.

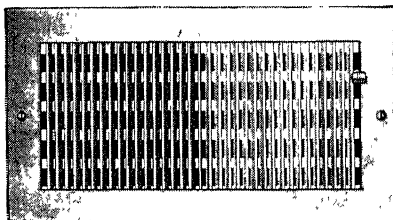
R & G ADJUSTABLE DIRECTED AIR FLOW TWO-WAY DEFLECTION



Use No. 3320 Grille for adjustable right and left deflection. Style 3310 has horizontal adjustable bars for up and down deflection.

THE "THIN MAN" REGISTER FOR RESIDENTIAL USE

Style 1108, shown, allows right and left deflection and up or down control at the back.



Other designs of faces are available.

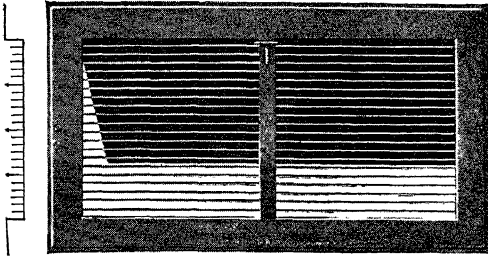
Ask for our catalog which shows other types of air controls; also 81 different Stamped Metal designs and over 100 designs in Cast Metals—Iron, Brass or Bronze.

United States Register Company

General Offices: **Battle Creek, Mich., U.S.A.**

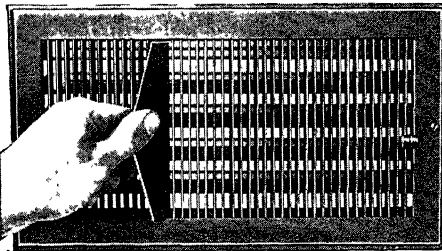
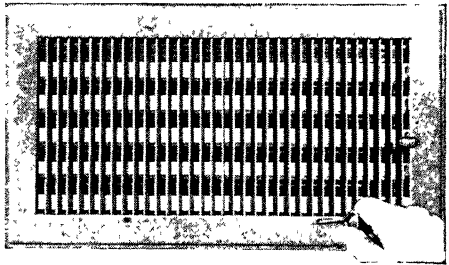
Branches: MINNEAPOLIS, MINN., KANSAS CITY, MO., ALBANY, N. Y., NEW YORK, N. Y.,
SAN FRANCISCO, CALIF.

Air Conditioning Registers, Vents and Grilles



Style 153LF—Louver-Type Air Conditioning Register—Bars $\frac{1}{4}$ in. deep—Spaced 4 openings to the inch affords Non-Vision. Can be supplied in Directional Flow in either Horizontal or Vertical Bar Styles. Can be furnished with all styles of Setting Frames.

Style 249LF—Duo-Deflection Air Conditioning Register. Gives complete Air Control. Vertical Front bars—Key-pin adjusted to provide 45 deg Right and Left or Two-way Side Flow. Lever operated Horizontal Back-valves give from Full Closed to any degree of Up-flow and to 45 deg Down-flow **FULL FACE COVERAGE**. Can be supplied with any style of Setting Frame. Fits all Stack Heads of Standard Size Dimensions.



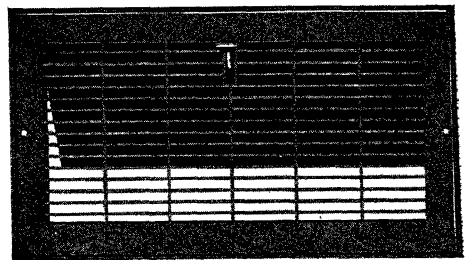
Style 256LF—Flex-bar Air Conditioning Register. Vertical Front Bars set 22 deg Right and Left. Side Flow Deflection attained by setting of Grille Bars with bending wrench to accommodate room condition. Back-valves give same Up and Down control of air flow as 249LF above. **FULL FACE COVERAGE**. Can be supplied with any style of Setting Frame. Fits all Stack Heads of Standard Size Dimensions.

All of above Styles can be supplied with either Lever or Individually adjusted Multiple Valves or Louvers. I. E. 153VVI—Vertical Valves Individually adjusted. 145VVL—Lever operated Vertical Valves.

Grilles and Vents in Matching designs are available.

**For Complete Information
Write for Latest Catalogs
with Engineering Data.**

In Canada, United States registers, vents and grilles are manufactured and distributed by the
CANADA REGISTER & GRILLE CO., Ltd., Toronto, Ontario

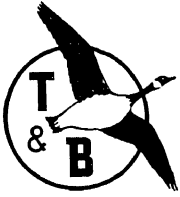


Style 103LF—Horizontal Lattice Perforated Register for Forced Air Systems. Not directional flow.

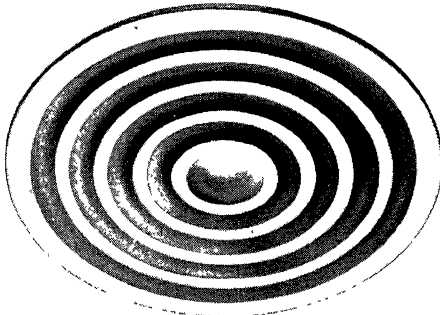
Tuttle & Bailey, Inc.

New Britain, Connecticut

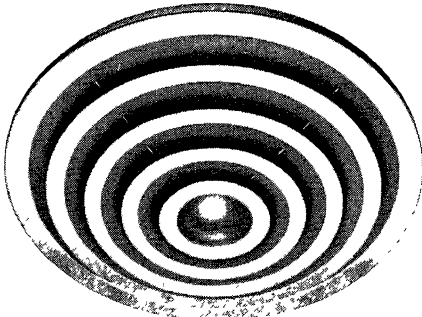
Branch Offices: CHICAGO, PHILADELPHIA, HOUSTON



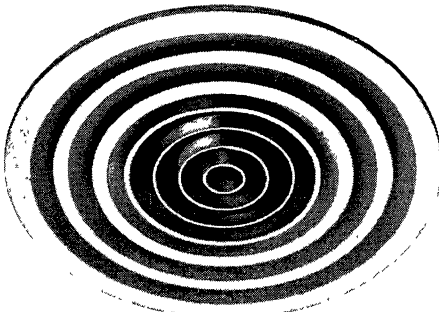
PRODUCTS: Ceiling Diffusers—Grilles—Registers—
Intakes—Air Control Devices—Ornamental Grilles,
Cast or Wrought Metals—Copper Convector Heaters



Type S1



Type E2



Type R1

AEROFUSE OUTLET

FOR HEATING
VENTILATING AND
AIR CONDITIONING

TYPE S

Flush-type diffuser for installation on ceiling. Perfect combination of real beauty and functional superiority. Provides (1) Maximum Air Mixture (2) Rapid Temperature Equalization (3) Perfect Air Distribution (4) Total Elimination of Drafts.

TYPE E

Type E Outlets are designed for installation on exposed ductwork and provide the same efficient performance as the S Type. The rings of Types E2 and E3 are stepped down, which greatly increases the capacity of a given size of outlet, resulting in an appreciable saving in the cost of the outlet and the ductwork.

TYPE R

Combination supply and return (or exhaust) unit. Designed particularly for use on installations where simplification of the duct layout is of primary importance since the return (exhaust) duct can be run to the same location as the supply duct.

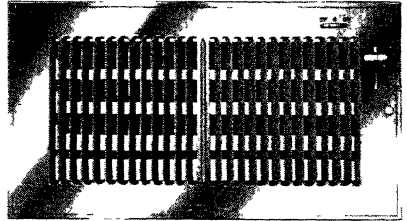
*Send for complete engineering data and
descriptive catalog*

Tuttle & Bailey, Inc.

New Britain, Connecticut

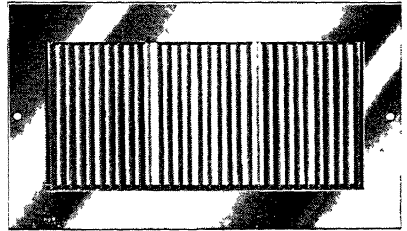
PLIAVANE ADJUSTIBLADE REGISTER

An inexpensive register suitable for war housing installations. The air flow may be directed sideways by the individually adjustable face vanes and up or down by the back blades which can be "set" from the face of the register itself.



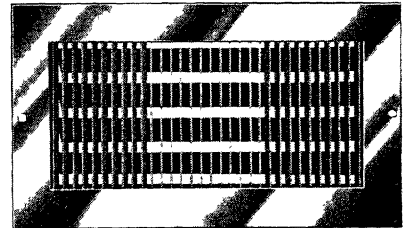
AIR CONDITIONING GRILLES

Furnished in both the fixed deflection (Airline Design) and the sectionally adjustable deflection (Flexair Design) types with bars running either horizontally or vertically. The Tuttle & Bailey Air Conditioning Grille is scientifically and sturdily constructed to perform efficiently under all operating conditions.



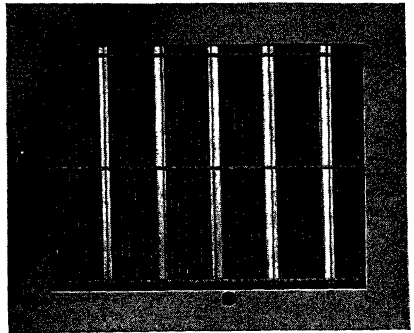
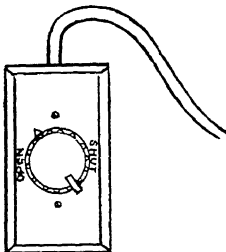
DOUBLE DEFLECTION GRILLES

Furnished with face bars of fixed (Airline) or adjustable (Flexair) deflection types and equipped with individually adjustable back blades. Also available with horizontal face bars and vertical back blades.



McKNIGHT VOLUME CONTROL REGISTER

Provides positive control of air volume at the outlet and eliminates necessity of duct dampers and diffusers. Scientifically designed louvres are easily and accurately adjusted by means of a special key furnished with each register.



REMOTE CONTROL

Ideal for hotels, office buildings, large manufacturing plants and public buildings. Provides an economical means of individual control of air volume at each outlet.

Waterloo Register Company

Waterloo, Iowa

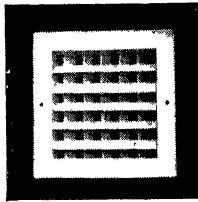
Seattle, Wash.

Incorporated 1902

Representatives in Principal Cities



Wire Mesh Grille especially designed for vessels, industrial plants, and Army barracks. Made of $\frac{1}{2}$ in. square mesh heavy wire with rugged frame.



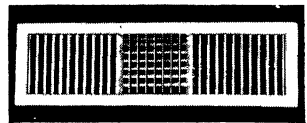
Adjustable Wood Louvre Grille to replace critical steel in Defense Plant installations. Available in three styles. Wood louvres are spaced on 1 in. centers with steel border and duct flange.



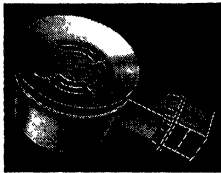
Return Grille G-2 with close mesh fixed directional fins. Fins set on $\frac{1}{4}$ in. centers in deflection desired. Also available with vertical fins.



FH-100 Forced Air Register for residential application. Simple operation, quick shut-off. Easy to clean.



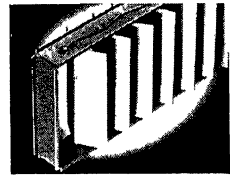
Supply Grille E-1 with both front and rear louvres streamlined and individually adjustable. $\frac{3}{4}$ in. blade spacing.



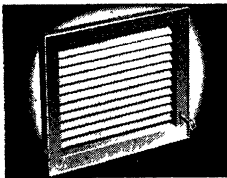
Zeph-O-Cone Marine Air Diffuser diffuses high entrance velocities rapidly and quietly. Sizes for 100, 150, 200 and 300 cfm at 2000 fpm inlet velocity.



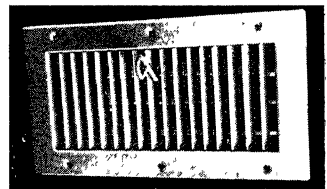
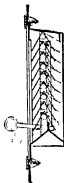
Techni-trol Air Volume Damper all louvres operate by linkage arrangement to reduce air volume without changing direction. Lever or key controls.



Techni-Louvre Air Control Device provides uniform distribution of air for entire outlet. Each vane is composed of two separate leaves independently adjustable. Dull Black finish.



Blackout Louvre is lightproof, sightproof, and weatherproof. Allows maximum passage of air while preventing escape of light rays. A convenient inside handle provides easy adjustment. It is made of steel, bonderized, and painted dull black. Available for vessels and industrial application.



Marine Supply Register with multi-louvre damper and ring loop for pole operation. Extra screwholes provided for stronger attachment needed on vessels. Friction points made of non-ferrous materials.

All products made of steel receive Parker "Bonderizing" process prior to painting.

Engineering Data for horizontal diffusion of cool air is available for selection of proper velocities, number and size of outlets.

The American Rolling Mill Company

Executive Offices, Middletown, Ohio

ATLANTA, GA.
1437 Citizens & Southern Natl. Bank Bldg.
BERKELEY, CALIF. Seventh and Parker Sts.
BOSTON, MASS. 201 Devonshire St.
BUFFALO, N. Y. 504 Seventeen Court St. Bldg.
CHATTANOOGA, TENN., 712 Chattanooga Bank Bldg.
CHICAGO, ILL. 310 S. Michigan Bldg.
CINCINNATI, OHIO. 24 Cooper Bldg., Hyde Park
CLEVELAND, OHIO. 1516 B. F. Keith Bldg.
COLUMBUS, OHIO. 1020 Atlas Bldg.
DALLAS, TEXAS. 1111 Santa Fe Bldg.
DAYTON, OHIO. 506 Mutual Home Bldg.
DES MOINES, IOWA. Room 703 Old Colony Bldg.
DETROIT, MICH. 5-261 General Motors Bldg.

HOUSTON, TEXAS. P. O. Box 2303
INDIANAPOLIS, IND. 1106 Fletcher Trust Bldg.
KANSAS CITY, MO. 7100 Roberts St.
LOS ANGELES, CALIF. 329 Petroleum Bldg.
MILWAUKEE, WIS.,
627 First Wisconsin National Bank Bldg.
MINNEAPOLIS, MINN. 171-27th Ave., S. E.
NEW YORK, N. Y. 120 Broadway
PHILADELPHIA, PA. 1808 Lincoln-Liberty Bldg.
PITTSBURGH, PA. 1627 Oliver Bldg.
ST. LOUIS, MO. 1725 Ambassador Bldg.
WASHINGTON, D. C.,
311 Defense Bldg., 1026-17th St., N. W.



Choose the Correct ARMCO Grade

These grades of ARMCO sheet metal are recommended for the air conditioning applications shown. For detailed information get in touch with the nearest district office or write direct to The American Rolling Mill Company, Middletown, Ohio.

ARMCO Ingot Iron (Galvanized)

Ducts
Washer Chambers
Plenum Chambers
Steam Line Casings
Furnace Casings
Spray Towers
Drip Pans
Housings
Machine Guards
Unit Conditioners
Roof Ventilators
Eliminator Blades

ARMCO PAINTGRIP (Galvanized)

A special mill-bonderized galvanized sheet that can be painted without pre-treatment. Preserves life and beauty of paint.

Hot Rolled (Sheets and Strip)

Fan Blades
Blower Casings
Fuel Oil Tanks
Unit Conditioners
Stoker Hoppers

ARMCO ZINCGRIP

A special zinc-coated sheet that can be severely formed without peeling or flaking of the tightly adherent zinc coating.

Cold Rolled (Sheets and Strip) Furnace Casings Room Unit Casings

Plates (ARMCO Ingot Iron) Smoke Stacks Coal Hoppers Breeching Unfired Pressure Vessels Low-fired Boilers Tanks

ARMCO High Tensile

A low alloy, high tensile steel possessing great strength. Used with proper design it results in weight reduction of framework, tanks and similar items. Under atmospheric service conditions it has four to six times the endurance of regular steel.

Stainless Steel (Sheets, Strip and Plate)

Combustion Chambers
Heat Flues and Tubes
Humidifier Pans
Pre-heaters
Furnace Parts and Supports
Fan and Blower Blades

Special grades have excellent resistance to destructive heat-scaling up to 2000 F.

Other ARMCO Products

The grades for these applications are only a few that ARMCO makes. Others include copper-bearing sheets and plates and open-hearth steel, either galvanized or uncoated.

BETHLEHEM STEEL COMPANY

GENERAL OFFICES: BETHLEHEM, PA.

DISTRICT OFFICES. AKRON, ALBANY, ATLANTA, BALTIMORE, BOSTON, BUFFALO, CHATTANOOGA, CHICAGO, CINCINNATI, CLEVELAND, COLUMBUS, DALLAS, DETROIT, HONOLULU, HOUSTON, INDIANAPOLIS, JOHNS-TOWN, PA., KANSAS CITY, MO., LOS ANGELES, MILWAUKEE, NEW HAVEN, NEW ORLEANS, NEW YORK, PHILADELPHIA, PITTSBURGH, PORTLAND, ORE., ST. LOUIS, ST. PAUL, SALT LAKE CITY, SAN ANTONIO, SAN FRANCISCO, SAVANNAH, SEATTLE, SPRINGFIELD, MASS., SYRACUSE, TOLEDO, TULSA, WASHINGTON, WILKES-BARRE, YORK. EXPORT DISTRIBUTORS: BETHLEHEM STEEL EXPORT CORPORATION, NEW YORK.



BETHLEHEM PRODUCTS FOR HEATING, VENTILATING AND AIR CONDITIONING

For the thousands of new men who are now moving into the sheet metal business to handle direct or indirect war jobs, we are listing the products which Bethlehem manufactures for heating, ventilating and air-conditioning. These products are, of course, subject to government priorities in all cases

Steel Sheets—Bethlehem manufactures a line of sheet steel to handle all types of heating, ventilating and air-conditioning jobs. Sheets are produced in the general classifications of hot-rolled (black), cold-rolled, and galvanized. Hot-rolled sheets are made in thicknesses from No. 18 gage to No. 2 gage, in widths varying with the thicknesses. Cold-rolled sheets are made in widths over 12 in. and in gages No. 11 to 30 inclusive. Galvanized sheets are made in gages 8 to 31 inclusive in widths of 24, 30, 36, 42 and 48 inches.

Bethlehem also produces galvanized steel roofing, siding and accessories. The designs include 2½-inch and 1¼-inch corrugated; 2-, 3- and 5-V crimp; Stormproof and Weatherproof patented designs; roll roofing and "plain brick" or "rock-faced stone siding." Accessories include valleys; corrugated end-wall and side-wall flashing; Stormproof starter, finisher and flashing; and ridge roll to fit all types of Bethlehem galvanized steel roofing sheets

Steel Pipe—Bethlehem now produces the new continuous-weld pipe, known as Beth-Co-Weld, in sizes from ½-inch diameter to 3-inch inclusive and in uniform 21-foot lengths, plus or minus one inch. This pipe is uniform in size, length, and physical characteristics. It will do a consistently good job wherever used.

Ammonoduct, a steel pipe which can be bent cold without annealing or danger of fracture, has long been a Bethlehem specialty. In peacetime it was used extensively for ammonia piping, heater coils, water legs in furnaces and similar uses where pipe must be bent. Will be available in quantity after the war emergency is over.

Boiler tubes, both lap-weld steel and charcoal iron are made by Bethlehem. These tubes are one of our oldest and most dependable products.

If you have a contract for heating, ventilating or air-conditioning, use dependable Bethlehem materials.



Steel from this giant mill will eventually become Bethlehem sheets.



Here's how the rolls of our continuous mill form Beth-Co-Weld Pipe

Jones & Laughlin Steel Corporation

Jones & Laughlin Building, Pittsburgh, Pa.

WELDED and SEAMLESS STEEL TUBULAR PRODUCTS

J & L Welded Pipe

Jones & Laughlin manufactures Standard Weight, Extra Strong, and Double Extra Strong Welded Pipe, Black and Galvanized, for steam, gas, air, water, refrigeration and sprinkler work. Sizes: $\frac{1}{8}$ in. to 16 in. O.D. inclusive.

J & L Copper-bearing Steel Pipe, when specified, can be supplied in standard weight, or extra strong, black or galvanized. Use of this product is recommended for long life, where piping is to be exposed to the atmosphere or other alternate wet and dry conditions.

Jones & Laughlin Steel Pipe is made of soft, weldable steel rolled from solid ingots made to a special analysis. The steel pipe produced is soft and ductile, free cutting, strong at the welds, and free from excess scale. J & L Pipe is commercially straight and free from blisters, cracks or other injurious defects.

Careful attention is given the threading of the pipe with good clean-cut threads fitted with sound couplings correctly tapped to give a tight joint. Soft, ductile steel of free cutting quality enables the contractor to cut clean, sound threads on the job.

The Jones & Laughlin process of galvanizing assures a thorough coating and insures against pipe being clogged with spelter. The galvanized coating adheres strongly and does not tend to flake off.

J & L Seamless Pipe

J & L Seamless Pipe is made in three weights; standard, extra strong and double extra strong. Sizes: $\frac{1}{2}$ in. nominal to 14 in. O.D. inclusive.

J & L Seamless Steel Pipe is pierced from a solid billet—there are no welds. The result is dependable and uniform wall strength. The method of manufacture, and the use of only specially selected steel, assure exceptional ductility, a quality that is essential to successful coiling and bending, and flanging for Van Stone joints.

J & L Seamless Pipe can be used with full satisfaction in either threaded joint or completely welded installations.



Ductility, strength and safety—make this product especially adaptable for air, steam, gas and gasoline lines, boilers, refineries, dry kilns, refrigerating systems and other exacting applications.

J & L Hot Rolled Seamless Steel Boiler Tubes

J & L Seamless Boiler Tubes are manufactured in accordance with the A.S.M.E. Boiler Code and comply with the A.S.T.M. Specifications and the rules and regulations of the Bureau of Marine Inspection and Navigation of the U. S. Department of Commerce. They are supplied in a full range of standard sizes, from 1 in. O.D. to 6 in. O.D. inclusive.

The process by which Jones & Laughlin manufactures seamless boiler tubes is largely responsible for the unusually high ductility of the product. It is a process in which a forging action is predominant, and produces a desirable combination of strength with a highly ductile nature. J & L tubes therefore are installed with ease and safety.

Other J & L Tubular Products

J & L also manufactures Reamed and Drifted Pipe in sizes 1 in. to 6 in. inclusive, Dry Kiln Pipe, Pipe for Refrigeration Service, Water Well and Irrigation Casing, Line Pipe and a complete line of Oil Country Tubular Products in welded and seamless.

Handbook on Standard Pipe

Available without charge or obligation, to heating and piping contractors and heating and ventilating engineers, is the J & L tubular products handbook SP5. In addition to containing catalog information of J & L Standard Pipe this book includes helpful engineering design data for contractors and engineers. Write on your letterhead for a copy of this convenient handbook.

United States Steel Corporation Subsidiaries

Carnegie-Illinois Steel Corporation, Pittsburgh and Chicago

Columbia Steel Company, San Francisco

Tennessee Coal, Iron & Railroad Company, Birmingham

United States Steel Export Company, New York

District Offices in all Principal Cities



U·S·S COPPER STEEL

For Superior Rust Resistance at Low Cost

Corrosion resistance and cost are two determining factors of the type of metal to be used for various air conditioning jobs.

Copper Steel has 2 to 3 times the atmospheric corrosion resistance of plain steel or pure iron as shown in the results of unbiased tests made at Pittsburgh, Ft. Sheridan and Annapolis by the American Society for Testing Metals.

The cost of U·S·S Copper Steel is less than that of pure iron or copper-bearing pure iron and only slightly more than plain steel. Thus there often is a dividend of 200 per cent to 300 per cent longer life and a saving in the first cost as well.

When galvanized, U·S·S Copper Steel produces a sheet that is rust resistant all the way through—not just on the surface. It should be used for all ducts carrying humidified air or placed in damp locations such as basements, shower rooms, etc.

U·S·S PAINTBOND

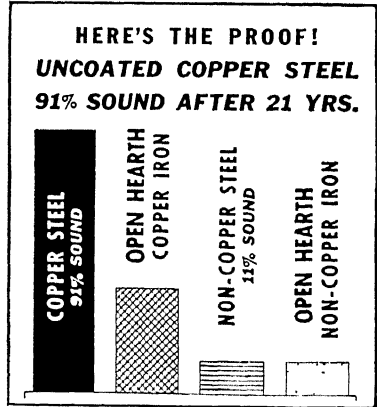
U·S·S Paintbond should be used whenever galvanized steel is to be painted. This special Bonderized sheet can be painted immediately, offers a much better surface for painting, lessens danger of the paint flaking and retards corrosion. It is used for ductwork, furnace housings and outdoor metal work.

Send for our Paintbond booklet.

U·S·S DUL-KOTE

U·S·S Dul-Kote is a specially treated non-spangled galvanized sheet which also can be painted immediately without ageing or otherwise preparing the surface. It is available in the South and in the West.

Send for our Dul-Kote booklet.



Corrosion test of A.S.T.M. on 22 gage black sheets exposed at Annapolis, Md., October, 1916. The copper steel sheets outlasted all others in the test.

OTHER U·S·S PRODUCTS INCLUDE:

Black Sheets—All grades, hot rolled, cold rolled in a number of different finishes.

Stainless—Heat resisting steel for various uses where temperatures are high and corrosion severe.

Cor-Ten—High Tensile steel—greater strength, greater atmospheric corrosion resistance for smokestacks, hoods, etc.

For more information on U·S·S Galvanized, Copper, Black and Stainless Sheets, send for our Guide for Sheet Metal Workers.

CONTROLS AND INSTRUMENTS



Automatic controls form an essential part of modern heating, ventilating and air conditioning equipment, and for the refrigerating equipment which performs important functions in many air conditioning operations. Their use makes possible accurate maintenance of desired physical conditions, with an operating efficiency and economy which are not obtainable with manually operated controls.

Instruments of many types and for many uses are available for determining the capacity and operating efficiency of apparatus. These instruments are designed to obtain results in conformity with adopted test methods and operating standards.

CONTROLS (p. 996-1018)

Thermostats—room, immersion, insertion and surface types; humidity controls, pressure controllers, damper motors, control valves, solenoid valves, relays, etc.

For control of air, gases, temperatures, humidity and liquids; for automatic fuel burning apparatus; for all types of heating, ventilating and air conditioning apparatus operating as separate units, or as integral parts of central systems.

The various types of automatic controls include electric, pneumatic, and self-contained control systems—two-position, or on-and-off, and the modulating or graduated control. They are adaptable for individual room control, or for zone control in large buildings, and also for industrial process control.

Technical data on automatic controls will be found in Chapter 34.

INSTRUMENTS (p. 996-1018)

For measuring, indicating and recording air velocity, temperature, humidity, pressure, flow and liquid levels; and for testing and rating heating, ventilating and air conditioning equipment.

They include gauges, meters, recorders and indicators, hygrometers, pyrometers, psychrometers, thermometers, velometers.

Technical data on instruments is contained in Chapter 35.

Manufacturer's products shown in this division are designed for specific applications. Consult the Index to Modern Equipment for additional products of these manufacturers.



Alco Valve Company

ENGINEERED REFRIGERANT CONTROLS

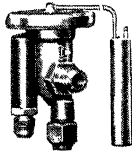
2638 Big Bend Blvd., St. Louis, Mo.

NEW YORK OFFICE 381 Fourth Ave

A complete line of Engineered Refrigerant Controls

THERMO EXPANSION VALVES

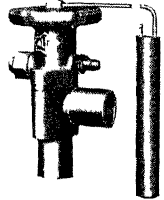
For automatic control of liquid refrigerant on all types of air conditioning and refrigeration systems.



Type TK



Type TJL



Type THL

CAPACITIES—From fractional tonnage to 100 tons Methyl Chloride, 50 tons Freon-12.

MAGNETIC STOP VALVES

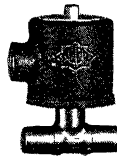
For all types of service

Magnetic Liquid Stop Valves

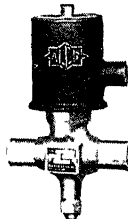
Freon—up to 75 tons, Methyl Chloride—up to 150 tons.

Magnetic Suction Stop Valves

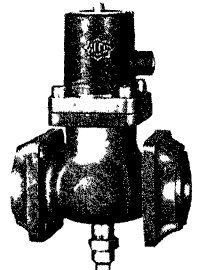
Freon—up to 1½" or 8.8 tons
Methyl Chloride—up to 1½"
or 17 tons



Type S1



Type M3



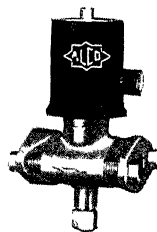
Type R2

AMMONIA CONTROLS

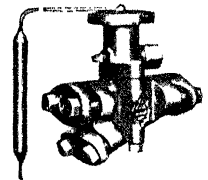
Magnetic Liquid Stop Valves —
up to 172 tons.

Magnetic Suction Stop Valves—
up to 1½" or 28 tons.

Thermo Expansion Valves—
from fractional tonnage to 60 tons.



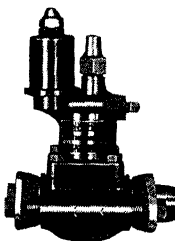
Type M5



Type TGS

EVAPORATOR PRESSURE REGULATORS

For Freon, Methyl Chloride and Ammonia, with port sizes up to 2 in., and a wide variety of connection sizes.



ALCO also offers Magnetic Stop Valves for brine, water, gas, air and steam; specially designed Magnetic Compressor Discharge Valves and Magnetic Pilot Check Suction Stop Valves (for lines subject to reverse Flow).

In addition, the Alco line of Engineered Refrigerant Controls includes Float Valves, Float Switches, High Pressure Float Valves, Constant Pressure Expansion Valves and liquid and suction line Filters.

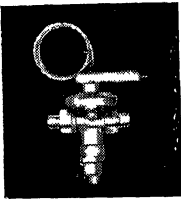
AUTOMATIC PRODUCTS COMPANY

2450 NORTH THIRTY — SECOND STREET
MILWAUKEE WISCONSIN

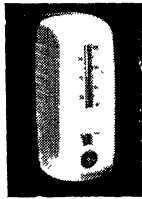


A-P DEPENDABLE CONTROLS

For Heating, Refrigeration and Air Conditioning

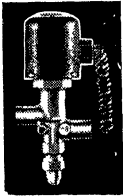
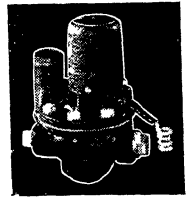


• A-P Thermostatic Expansion Valves. Several models and sizes, for capacities up to 16 tons Freon or 32 tons Methyl Chloride.

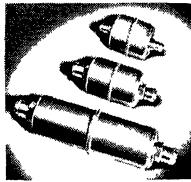


A-P Thermostats.
For Cooling or Heating

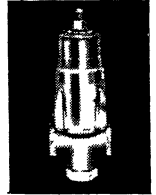
A-P Solenoid • Operated Water Valve. Made especially for Deep Well Cooling.



• A-P Solenoid Refrigerant Valves. Capacities up to 50 tons Freon.



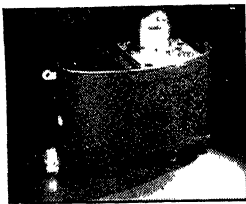
A-P Water • Regulating Valves. Capacities up to 1440 Gallons per hour.



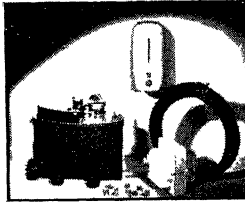
A-P "Trap-It."

Traps dirt, scale, moisture in refrigeration systems.

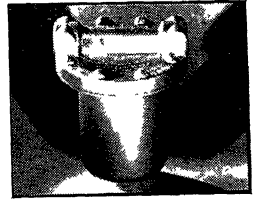
A-P Controls for Oil Burning, Gravity-Feed Heating Plants.



A-P Constant Level Oil Control Valve—With Fuel Compensator. Used on Gravity Oil Burning Appliances.



A-P Complete Furnace Control Set—Made in variety of types for Gravity-Feed Oil Burning Furnaces.



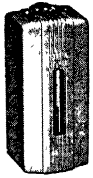
A-P Fuel Oil "Trap-It"—Traps dirt and water in fuel systems. Improves operation of all oil burning devices.

A-P Valve DEPENDABILITY

is widely recognized in Refrigeration, Air Conditioning and Heating. This reputation is born of close adherence to a rigid standard of perfection—in materials used, careful testing and inspection, simplicity of construction, and many unusual features.

Barber-Colman Company Rockford, Illinois

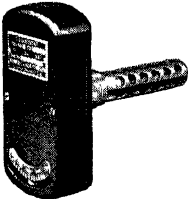
Automatic Control Systems for Heating, Ventilating, Air Conditioning



Room Type
Microtherm



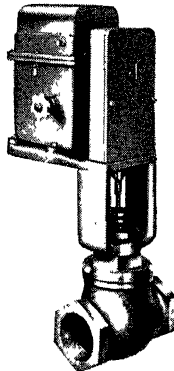
Room
Thermostat



Duct Thermostat



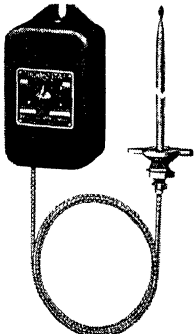
Hygrostat



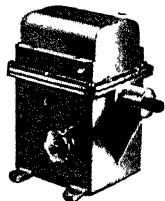
Motor-operated
Proportioning Valve



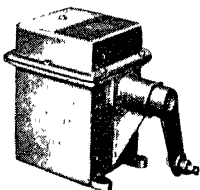
Motor-operated
Shut-off Valve



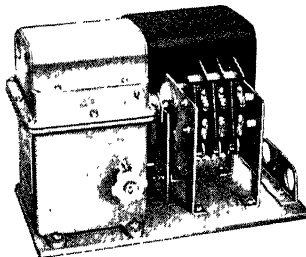
Remote Bulb Thermostat



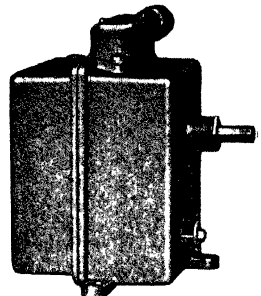
Proportioning Type
Control Motor



Stall Type Control Motor



Program Switch



Heavy Duty Industrial Type
Control Motor

Barber-Colman Controls are all electric; precision built to insure long, continuous and dependable service; easy to install in either new or existing buildings; and ready for instant service, even after long shut-down periods.

Thermostats. All types—room, duct, immersion, air stream and remote bulb. For 2-position, floating, and proportioning control.

Hygrostats. Room and duct types.

Motor-Operated Valves. Packless, packed single-seat, pilot piston, V-ported, balanced, 3-way, and butterfly. For 2-position, floating, or proportioning control. Also Solenoid Valves for air, oil, water and gas. *Motor-operated valves are powered with Barcol motors which have only one moving part and require no attention except oiling; oil submerged operators require no attention.*

Control Motors. Uni-directional, or reversible fixed or adjustable speed. For 2-position, floating or proportioning operation of dampers in heating, ventilating or air conditioning applications. *Oil submerged models have the motor and gear train entirely submerged in oil.*

Program Switches. Automatic contact making mechanism for multi-compressor control or similar applications.

Econostat (not illustrated), a complete self-contained thermostatic unit for automatic regulation of the heat supplied to a building in accordance with outdoor temperatures.

Write for descriptive literature.

**LISTED AS STANDARD BY
UNDERWRITERS LABORATORIES**

(See also Page 980)

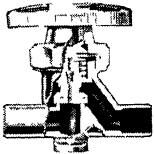


Henry Valve Company

1001-19 North Spaulding Ave., Chicago, Ill.

Manufacturers of

PACKLESS AND PACKED VALVES • DRYERS FOR REFRIGERATION AND AIR CONDITIONING • STRAINERS • AMMONIA VALVES • FORGED STEEL VALVES AND FITTINGS FOR OIL, STEAM AND OTHER FLUIDS.

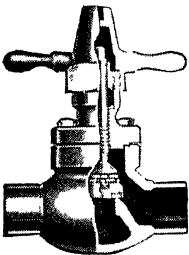


**Balanced-Action
Diaphragm
Packless Valves**

VALUE OF BALANCED-ACTION

Regardless of operating conditions or the differential in the pressure above and below the valve seat, balanced-action assures positive and instantaneous opening. The balancing action is really the equalizing of the pressures on the two sides of the valve seat at the instant of opening. This is accomplished by a channel in the axis of the valve stem. When the valve is closed, the upper port of this channel is sealed by the diaphragm assembly itself. At the instant of opening, the pressure above the seat forces the diaphragm assembly upward, exposing the upper port of the balancing channel. The pressure is released through the channel to the region below the seat, equalizing the pressures, thus assuring positive opening. A spring-tensioned ball check seals the channel for diaphragm inspection.

Other Important Features are: Oval hand-wheel, ports-in-line, non-rotating bearing plate to protect diaphragm from rotating friction of stem, and use of multiple puncture and fracture-proof diaphragms designed to resist wear and corrosion. Available in a complete range of sizes with flare and solder connections.



WING CAP VALVES

Designed especially for Freon and Methyl Chloride. Have patented rotating self-aligning stem disc. Special resilient packing. May be repacked under pressure. Wing cap can be inverted and socket used for operating valve.

Made of non-ferrous alloy to meet government specifications. Solder connections machined directly in valve body.

ABSO-DRY PRESSURE SEALED DRYERS

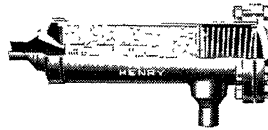
For Refrigeration and Air Conditioning
The exclusive Henry vacuum process first removes every trace of moisture, then the

dryer is charged with dehydrated air. Loosening a seal cap prior to installation produces hissing sound, a guarantee of original factory dryness and freedom from leaks



OTHER FEATURES OF HENRY DRYERS—*Perforated Dispersion tube* is connected to inlet port and exposes entire volume of dehydrant to penetration by refrigerant. *Minimum pressure drop* No channelling. *Compression Spring* maintains uniform tension on dehydrant at all times and compensates for changes in volume. *Soldered or Flanged Shells*—models are available with either soldered cap or flanged end shells. Flange is distortion-proof. Shells not exceeding 5½ in. in length are drawn in dies, so that they have only one joint.

TWO DEHYDRANTS—Choice of the two most popular dehydrants at same price: Activated Alumina or Silica gel.



**Type 757
Cartridge
Dehydrator**

A flanged shell dehydrator with replaceable cartridge.

**Type 712
Dehydrator**



Soldered brass shell dehydrator with dispersion tube.

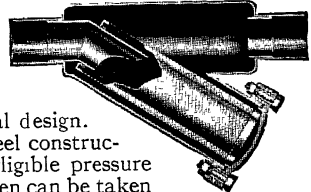
HENRY STRAINERS

There is a size and type of Henry Strainer for every installation requirement.

Type 895 "Y" Strainer

With solder fittings for use with copper pipe. Exceptional design.

Welded steel construction. Negligible pressure drop. Screen can be taken out for cleaning without removing strainer from line. Very large screen area. Light weight. Baffle prevents heavy particles injuring screen.



APPROVED FOR ARMY AND NAVY USE

Detroit Lubricator Company

Detroit, Michigan, U. S. A.

NEW YORK, N. Y., 40 West 40th Street

CHICAGO, ILL., 816 S Michigan Avenue

LOS ANGELES, CALIF., 320 Crocker Street

Canadian Representative:

RAILWAY AND ENGINEERING SPECIALTIES LIMITED, Montreal, Toronto, Winnipeg

Air and Vent Valves



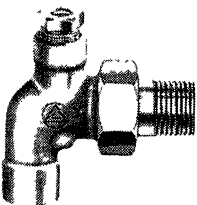
No. 861

The "DL" line of air and vent valves is one of the broadest on the market. The Ideal Fast Venting System, using the No. 300 Multiport and the No. 861 Hurivent (illustrated) is particularly advantageous on one pipe steam jobs fired automatically and makes possible complete venting of the system in the shortest time, together with even heat distribution to all radiators. The No. 300 valve is limited to systems operating at less than 3 pounds pressure. The No. 5000 Airid Variport is an adjustable valve for systems which must operate at more than 3 pounds pressure. The No. 841 Ideal Quick Vent is an inexpensive fast venting main vent. For hand-fired coal jobs operating on vacuum, there is the No. 510 Vac-Airid Air Valve; the No. 862 Vac-Hurivent, and the No. 842 Vac-Vent for mains. Write for Bulletin No. 197.

Radiator Valves and Balancing Fittings

The broad line of "DL" radiator valves, both packed and packless, covers many types and sizes. All valves are sturdily built and have clean-cut threads and accurate dimensions. Hot water valves feature the patented "swinging plate" design, which eliminates restriction to flow and always turns freely.

A line of specially designed valves and balancing fittings for forced circulation hot water systems is also available. With "DL" balancing elbows or straightway fittings, the heat output from each radiator may be controlled by a screw driver adjustment without the necessity of draining the system.



No. 233

"DL" special circulator type valves are designed to close off tight enough to prevent heating of radiators when so desired, but allow a small leakage to avoid freezing. Write for Bulletins 56 and 85.

Automatic Controls

Detroit Lubricator Company manufactures a very complete line of electrical controls, designed to open or close an electrical circuit with changes of temperature or pressure. The No. 411 Thermostat (illustrated) is a low voltage model and is made in plain and Day and Night types. All No. 411 Thermostats are available with heat compensation to provide smooth, accurate temperature control. The No. 855 Mercoid Room Thermostat (illustrated) is a line voltage type—available in heating, air conditioning and refrigeration ranges.



No. 411

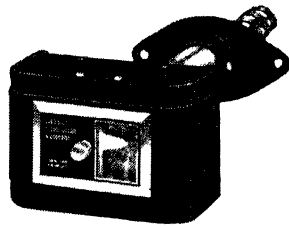
For industrial use the No. 250 and No. 450 line of pressure and temperature controls is available, in pressure ranges from 20 in. vac. to 350 lbs., and in temperature ranges from -30°F. to 495°F.



No. 855

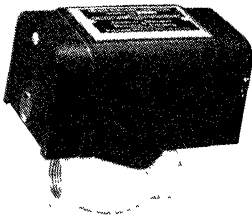
Also available is a full line of blower controls, combination blower and limit controls, such as the CA-815 illustrated, and a special line of water-tight equipment for use in wet locations.

There is a "DL" control available for practically every application where a dependable device is required to open or close an electrical circuit with changes of pressure or temperature. Write for complete information. Our Engineering Department is always ready to make recommendations on any specific problem.



No. CA815

Gas Valves

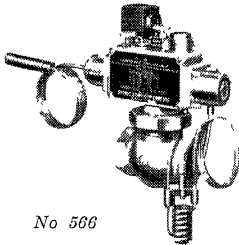


No. V-570

The No. V-570 Electric Gas Valve is an electrically operated valve for control of gas lines from $\frac{1}{2}$ to $1\frac{1}{4}$ in. It provides partial opening upon initial operation, permitting

quiet ignition of gas. Inexpensive, compact, and attractive in appearance, it employs an easily serviceable bimetal strip motor for actuating force. Write for Bulletin 201.

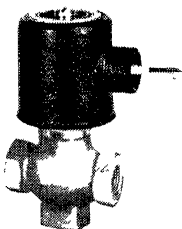
The No. 566 Valve combines in one compact unit all of the functions of a control system for gas heating. All safety functions are mechanical and operate independent of electric current. Adjustable for full snap or any degree of throttling action. Limit control closes valve with a snap action. Valve may be manually operated in case of current failure. Applicable to all gases, natural, manufactured, or mixed. Write for Bulletin No. 80.



No. 566

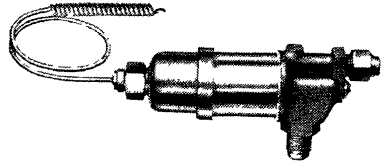
Solenoid Valves

"DL" Solenoid Valves for control of water, air, oil, gas, or refrigerant, embody many desirable features. They are free from A.C. hum and will open against high pressures. Available in all standard voltages and cycles A.C. or D.C. No. 683-3 is a small size valve with $\frac{3}{8}$ in. connections. No. 681 (illustrated) is a pilot operated, intermediate size valve, and the No. 686 is a large pilot operated valve with capacity up to 17 tons Freon.



No. 681

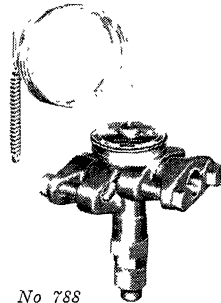
No. 686 valve available with flanged connections. No. 681 and 686 are furnished with manual opening feature to permit opening in case of current failure. All models may be taken apart and cleaned in the field without removing from pipe lines. Write for Bulletin No. 199.



No. 673

Expansion Valves

"DL" Thermostatic Expansion Valves are designed to keep the evaporator in a refrigerating system completely refrigerated. All power elements are "gas charged" to a definite pressure, preventing motor overload and providing quicker response and more sensitive control. Capacities from $\frac{1}{8}$ ton to 30 tons Freon. The No. 673 valve employs a double bellows as the actuating means, while the Durafram line is constructed with a single diaphragm power element. All needles and seats are made of Delubaloy, a very hard, corrosion resistant alloy to insure long, trouble-free service. Write for Catalog No. 200 on refrigeration equipment.



No. 788

Air Filters

Detroit Air Filters are of the replacement type. They are highly efficient and have a very low initial resistance. The entire depth of filter is used in cleaning the air.

The adhesive used remains tacky at 0°, will not drip at 180° and will not vaporize at 300°, is odorless, and will not become rancid. Filters may be returned to factory for cleaning and renewing at a substantial saving. Write for Bulletin 187.

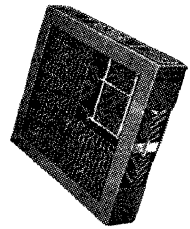
Standard Filter Sizes*

STANDARD SIZES
NOMINAL

20" x 25" x 1"
20" x 20" x 1"
16" x 25" x 1"
16" x 20" x 1"

20" x 25" x 2"
20" x 20" x 2"
16" x 25" x 2"
16" x 20" x 2"

*Special sizes also available.



Detroit Air Filter

The Fulton Sylphon Company

Manufacturers of Sylphon Automatic Temperature Controlling Instruments and Packless Expansion Joints

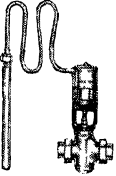
Sales Representatives
in Principal Cities

Knoxville, Tenn.



HOT WATER SUPPLY

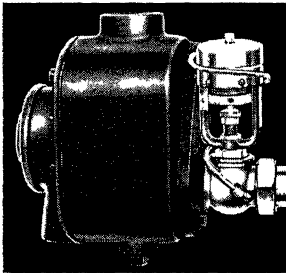
No. 923 Temperature Regulator—For controlling water temperature in heaters, open or closed tanks and other equipment. Operation unaffected by temperature fluctuations at the valve, either above or below bulb temperature. All parts, except steel adjustment spring, made of non-ferrous metals. May be installed in any position. Ranges from 40–80 F to 290–330 F. Bulletin HVG-20.



No. 923
Temperature
Regulator

Sylphon Thermostatic Water Mixers

Utilize hot water from any storage tank or instantaneous heater, and effectively



No. 902 Sylphon Thermostatic
Water Mixer—14 to 131 gpm
depending on water pressure

regulate the amount of cold water required to temper it to the desired degree, actually mixing the hot and cold water together before delivery. Temperature remains constant in spite of fluctuations in supply water temperatures or pressures.

Four sizes with capacities ranging from 5 to 131 gpm. Bulletin HVG-40.

REFRIGERATION CONTROLS



No. 945-Z
Regulator

Adaptable wherever brine is used as the refrigerant. Latest development is a "freeze-proof" valve (illustrated at left on the popular Sylphon No. 945-Z Regulator). Bulletin HVG-20.

PACKLESS EXPANSION JOINTS

The Sylphon Packless Expansion Joint eliminates useless building height, expensive construction and non-revenue producing space. No costly leaks and repairs, no repacking, always tight, allows heating system to operate at full efficiency. Write for Bulletin HVG-140.



No. 110
Sylphon
Expansion
Joint

SPACE HEATING CONTROL

No. 885 Automatic Radiator Valve—For exposed radiation. Small, neat, finely finished, adjustable to room temperature desired.

Simply replace ordinary radiator valves with these Sylphon Automatic Regulators—no wiring, piping or auxiliary equipment are required. These valves answer the demand for an inexpensive means of providing accurate, dependable space temperature control in



Sylphon No. 885
Automatic Radiator Valve

rooms, sections or throughout large buildings, new or old. Similar type valves for concealed radiation — get Bulletin HVG-80.

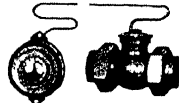
No. 890 Electric Radiator Control Valve—For either exposed or concealed radiation. Similar in appearance and action to Sylphon Automatic Valves, but operated by an electric wall thermostat.

The closing of the thermostat circuit energizes a low voltage electric heater coil surrounding a bulb containing a volatile liquid. This liquid expansion causes pressure on a bellows in the valve head operating the valve. This provides radiator valve control from a remote location, permits regulation of several radiators from a single thermostat, enables a time switch to be installed, if desired, offers effective zone control of large areas at a fraction of the cost of conventional motor-operated valve systems. Bulletin HVG-70.



Sylphon No. 890
Electric
Control Valve

No. 7 Temperature Control—A self-contained, self-powered regulator for controlling unit heaters, wall or ceiling type radiators, heating coils in duct-type heating systems, etc. Quickly installed, holds temperatures within close limits. Valve placed in steam line to one or a battery of heaters, thermostat mounted on wall or column.



Sylphon No. 7
Temperature Control
(Self-operating)

For use on regular heating pressures up to 15 lb. Similar regulators, Nos. 7-2 and 7-3 for 50 and 75 lb pressure and temperatures up to 170 F. Bulletin HVG-50.

HEATING AND AIR CONDITIONING CONTROL

Almost any type of heating, ventilating or air conditioning system can be advantageously controlled wholly or in part by Sylphon Regulators. Basic advantages of Sylphon Controls are:

Modulating—Maintains ideal conditions—not continually correcting too hot, too cold, too humid or too dry conditions.

Compensating—Many Sylphon Regulators offer compensating control, automatically raising their low limit setting at

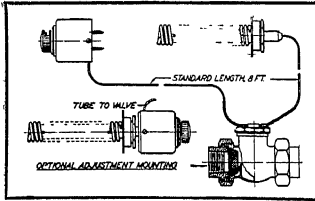
a predetermined rate as outside temperatures fall.

Sensitive—Close operating temperature differentials. Quick response.

Simple—in design.

Rugged Construction—To give years of satisfactory service.

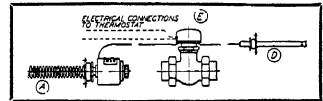
Adaptable—Any one of many combinations of Sylphon Instruments can be arranged to control any air conditioning system and to provide exactly the conditions desired. Write for Bulletin SAC-820.



Regulator 928-C

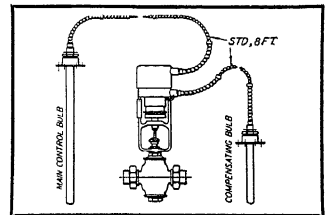
The No. 928-C Regulator—Simple, compact yet highly sensitive. Suitable for modulating control of air temperatures in ducts. Bulb is constructed of numerous coils of copper tubing giving sensitivity to the slightest temperature variation. Packless valve eliminates service problem and makes this regulator ideal for installation in inaccessible locations. Suitable for steam pressures up to 15 lb; other types available for pressures up to 75 lb.

The No. 928-ECC Sylphon Instrument—Room control and low-limit control in a single valve regulator for modulating control of ventilating systems. Main control from an electric room thermostat operating through the electric head "E" on the valve. Low-limit control by Bulb "A" located in discharge duct from the heater. Bulb "D", located in inlet side of the duct to the heater, compensates Bulb "A". Compensating thermostat can be furnished to raise low-limit setting at predetermined rate with falling outside temperature. Suitable for steam pressures up to 15 lb.

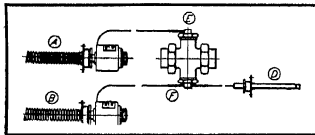


Instrument 928-ECC

Sylphon No. 971 Differential Regulator—For controlling room temperature on the cooling cycle, where chilled water or brine is used as cooling medium and where it is desired to have a gradual increase in room temperature as outside temperature increases. This regulator is modulating in action, thereby affords better control over humidity than is procured when usual on-and-off type control is employed.



Regulator 971

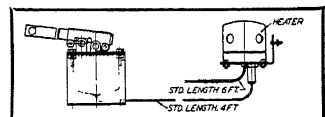


Control 889-C

The Sylphon No. 889-C Control—A modulating, dual-function regulator for control of duct heating and ventilating systems—two independent valves in a single body.

Adjustable Thermostat "A" governing Valve "E" functions to maintain room temperature from temperature of recirculated air. Adjustable Thermostat "B" acts as a low-limit ductstat controlling Valve "F" to maintain minimum discharge air temperature. Bulb "D" compensates Bulb "B" to maintain even discharge air temperature irrespective of demand. Compensated Thermostat "B" can also be furnished to raise its setting at a predetermined rate with falling fresh air temperatures, if desired. Suitable for steam pressures up to 15 lb.

Sylphon No. 371 Positive Type Damper Motor—On-and-off control of dampers. Operation controlled by room thermostat, by hand-operated switch, by motor starting switch, etc. Advantages include: (a) motor returns to closed or safety position in event of current failure; (b) heat-motor bulb and motor separate enhances convenience of installation; (c) damper motor lever adjustable; (d) positive, powerful operation.



Damper Motor 371

Johnson Service Company

AUTOMATIC TEMPERATURE AND AIR CONDITIONING CONTROL

General Offices and Factory

Milwaukee, Wis.

Branch Offices in all Large Cities

JOHNSON TEMPERATURE REGULATING CO OF CANADA, LTD., 113 SIMCOE ST., TORONTO, ONT.
HALIFAX, N. S. MONTREAL, QUE. WINNIPEG, MAN. CALGARY, ALTA. VANCOUVER, B. C.

PRODUCTS AND SERVICES

Manufacturers, Engineers, and Contractors—For automatic temperature and humidity control systems applied to all types of heating, cooling, ventilating, and air conditioning installations

Space Control—Automatic control of room temperatures and humidities, applied to radiators, unit ventilators, unit heaters, and heat delivery ducts. Johnson "Duo-Stats" to maintain the proper relationship between outdoor and heating system temperatures for groups of radiators, or "heating zones." A complete line of devices for automatic control of air conditioning systems, heating, cooling, humidifying, dehumidifying.

Process Control—Automatic temperature and humidity control devices for manufacturing and industrial processing, applied to tanks, dryers, vats, kettles, curing rooms, coolers, kilns, etc

Nation-wide Service—Johnson sales engineers, technicians, and trained installation men are available at all branch offices. None of the men in the nation-wide Johnson organization are agents, jobbers, or part-time representatives. All are salaried employees, devoting their entire efforts to the interests of the JOHNSON SERVICE COMPANY and its customers.

Send for Bulletins describing the detailed characteristics of any of the Johnson devices.

JOHNSON THERMOSTATS

Room Thermostats—Intermediate (gradual) or positive (snap) action, maintaining temperatures accurately within one degree above or below point of setting. "Dual" (two-temperature) and "Summer-Winter" types, as well as standard instruments. Various types of covers allow wide selection of adjusting features, guards, and method of mounting. Red-reading thermometers with magnifying tube attached to each cover.

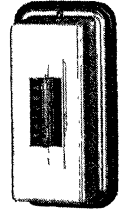
Insertion and Immersion Thermostats—Control temperatures in ducts, tanks, and similar locations. High grade insertion or immersion thermometers for mounting adjacent to the thermostats, including the distinctive Johnson "Sunrise" insertion thermometer, with red-reading mercury column in heavy lens glass tube and 9-in. scale with patented adjustable tilting feature

Extended Tube Thermostats—Mercury or vapor tension type, to sense temperatures at a point remote from the location of the operating mechanism. Various types of bulbs. Connecting tubing up to 50 ft in length for vapor tension, 75 ft for mercury actuated systems.

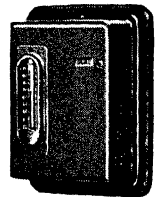
Special Thermostats—For applications encountered in industrial control, including the "Record-O-Stat," combination extended-tube temperature controller and recorder. Full 10-in chart and vapor tension or mercury actuated systems. Single or duplex type, the latter controlling and recording both wet and dry bulb temperatures.

Remotely Adjusted Thermostats—A distinctive Johnson feature, applied to various types of instruments where readjustment must be accomplished from a remote point, such as another thermostat or a manual switch.

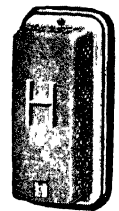
Johnson Sensitivity Adjustment—An important development in automatic temperature and humidity control for air conditioning. A unique and convenient means of adjusting the sensitivity of Johnson thermostats and humidostats, on the job, balancing "time-lag" with respect to the capacity of conditioning apparatus. "Hunting" and temperature fluctuation prevented. Available on all Johnson gradual action insertion and immersion thermostats, insertion humidostats, and certain room type thermostats and humidostats.



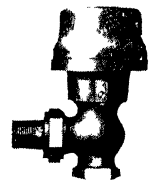
Single Room Thermostat



Dual Room Thermostat



Room Humidostat



"Sylphon" Radiator Valve

JOHNSON HUMIDITY CONTROL

Johnson Humidostats—Automatically control the supply of moisture delivered by a humidifier or by other means, maintaining a constant percentage of relative humidity. Available in both room and insertion patterns and with various types of elements as determined by requirements, the most sensitive controlling within 1 per cent at relative humidities as high as 95 per cent at 100 F. Humidostatic elements are wood-strip, human hair, animal membrane, or other suitable substances as selected.

Johnson Humidifiers—"Steam grid" type (perforated pipe supplied with low pressure steam) or pan type with copper evaporating pan, brass heating coils, and float control.

JOHNSON VALVES

Johnson Diaphragm Valves—Simple and rugged. Seamless metal bellows and heavy spring operate the valve stem. Available, if desired, with diaphragms of special molded rubber, resistant to aging, heat deterioration and oxidation. No complicated moving parts. Made in all standard sizes and patterns. Direct acting (normally open) or reverse acting (normally closed). Also, three-way mixing and by-pass valves. For steam, water, brine, and freon.

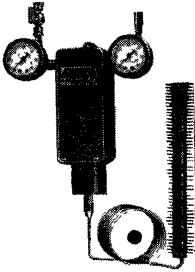
Johnson "Streamline" Diaphragm Valves—Modulating discs and special internal construction, insure superior gradual control . . . Where maximum power is required for repositioning at the slightest demand of controlling instruments, Johnson molded rubber diaphragm valves are fitted with Johnson's dependable pilot feature, for smooth gradual operation, independent of friction and pressure variations.

JOHNSON DAMPERS AND SWITCHES

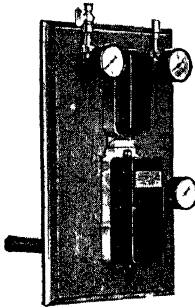
Standard Johnson Dampers—Steel blades in flat steel frames with adequate bracing to form a rigid assembly. Finished in two coats of black lacquer. Special corrosion-resisting finishes on order. Angle iron frames optional. **Special Dampers**—Galvanized iron, monel metal, aluminum, copper, rust-resisting steel, etc. Brass pins in steel bearings or ball bearings.

Johnson Damper Motors—In principle, similar to valves. Seamless metal or specially molded rubber diaphragm operates damper through suitable linkage. Various types of brackets. Distinctive Johnson "Piston-type" damper motors afford long travel at full power, a feature not found in other such devices. With or without pilot mechanism, as described above under "Valves."

Johnson Pneumatic Switches—Various patterns for operation of dampers and for placing thermostats and other devices in and out of service, as required, from remote points. Standard switchboards are oiled slate. Ebony asbestos, polished oak, and genuine or imitation marble on order.



*Extended Tube
Thermostat*



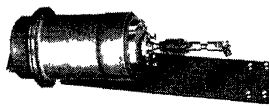
*Remotely Adjusted
Duct Thermostat*



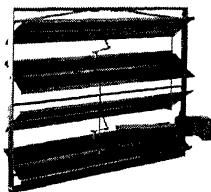
*Modulating Attachment
for Expansion Valves*



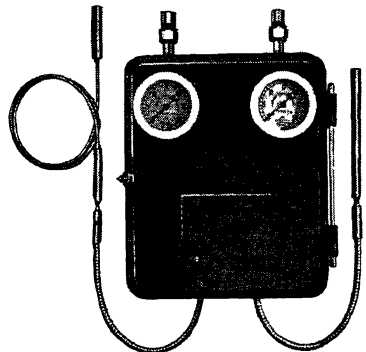
*Rubber Diaphragm
Coil Valve*



Piston Type Damper Motor



Lowered Damper

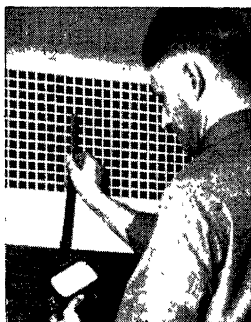


Johnson "Duo-Stat"

Illinois Testing Laboratories, Inc.

422 North LaSalle Street, Chicago, Illinois

Manufacturers of
Pyrometers, Thermometers, Temperature Controllers
Air Velocity Meters.



Velometer with averaging jet used for checking velocity from supply grille. Tube is attached to left side.

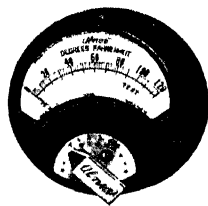
“ALNOR” VELOMETERS

This instrument measures directly and instantaneously air velocities without the use of stop watches or mathematical calculations. It will help you to locate drafts and leaks around windows and doors, or in duct systems. This instrument is manufactured in a variety of ranges for many different applications, such as for static pressure and total pressure measurement, as well as velocities within ducts or the face of a grille.

For accurate velocity readings at exhaust grilles, a new type of jet is now offered for use with the Velometer. This jet compensates for the change from static pressure to velocity pressure at or near the face of the grille.

“ALNOR” DISTANT READING ELECTRIC THERMOMETERS

This type of Thermometer is used in air conditioning installations, as well as heating and refrigeration installations. The instrument is mounted in the engine room or in the office of the building, and the temperature measuring elements are located in various remote points around the building or on the roof, and merely by slipping the switch into various positions, the temperatures at these remote points are instantly measured.



“Alnor” round type multi-point resistance thermometer with built-in switch.

“ALNOR” PYROMETERS

A wide variety of portable and wall mounting Pyrometers is available in the “Alnor” line. Temperatures of molten metals or temperatures of heat treating furnaces or any surface temperatures can be obtained swiftly, surely and simply by using “Alnor” Pyrometers.

Regardless of what your temperature measuring application may be, there is an “Alnor” instrument to take care of it for you.

Ask for an “ALNOR” Catalog
The Products of 42 Years Experience

Leeds & Northrup Company

General Office and Works: 4941 Stenton Avenue, Philadelphia, Pa.

Branch Offices:

BOSTON
BUFFALO
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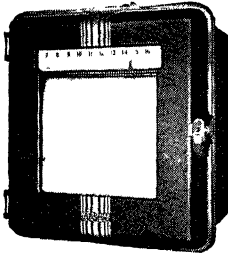
CLEVELAND
DETROIT
HARTFORD



HOUSTON
LOS ANGELES
NEW YORK

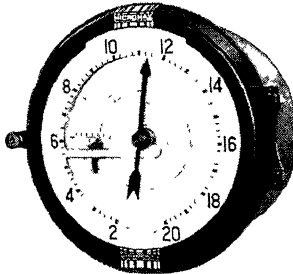
PITTSBURGH
ST. LOUIS
SAN FRANCISCO
TULSA

RUGGED, ELECTRICAL-BALANCE INSTRUMENTS



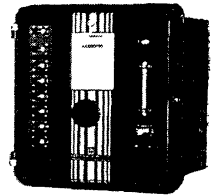
Model S Micromax Recorder

Records from 1 to 16 points on a single strip-chart. Extremely open record. Can operate signals. (About 1/15th size)



Model R Micromax Recorder

Records 1 or 2 points on a round-chart. Has extremely readable dial. Can operate signals. (About 1/15th size)



Panel Indicator

Hand-operated. Can be connected through selector switches to any number of points. (About 1/12th size)

Electrical Thermometers for Air Conditioning

No method for measuring temperatures fits the specific needs of air conditioning as does the three-lead, null-type resistance thermometer method. It is independent of distance and disregards all temperatures except those right at points of measurement. Thermohms (electrical resistance thermometers) can be placed anywhere—in rooms, air ducts or water lines. They are connected by simple electrical wiring to instruments at a central location. Instruments may be: Micromax Recorders, Model S for up to sixteen Thermohms, Model R, for related pairs such as wet and dry bulb; indicators with switches for any number of Thermohms; or indicating and recording combinations.

Sound in principle, this equipment is reliable in operation. Instruments and Thermohms are highly responsive, yet rugged in construction. A complete system is easy and economical to install, regardless of distances. It is easy to operate and demands minimum maintenance. Thermohms and instruments are interchangeable, and can be replaced without disturbing wiring or returning anything to the factory.

L&N Resistance Thermometers make it possible to operate efficiently; to maintain comfort or correct process atmosphere constantly . . . so that maximum return is realized on the conditioning investment.

Jrl Ad N-225(2)

Electrical Instruments for the Steam Plant

The facts needed to operate a modern heating plant so as to save fuel, to protect equipment, and to operate efficiently at varying loads are provided reliably by rugged L&N instruments. Readings can be indicated or recorded or both. Recorders can be equipped to operate signals or alarms that warn the operator of extreme conditions. In some cases the instruments control automatically.

Micromax Model S provides a permanent record of conditions at from 1 to 16 points on one wide-scale chart. Micromax Model R concentrates on conditions at one point, provides a permanent record, has a giant indicating dial that can be read at a glance. A Panel Indicator provides intermittent checks on conditions at one or several points.

In the heating plant, L&N measuring, signalling or controlling equipment is used for:

- Metermax Combustion Control
- Furnace Pressure Control
- Smoke Density Analysis
- Flue Gas Analysis (Per Cent CO₂)
- Flue Gas Temperatures
- Steam and Water Temperatures
- Boiler-Furnace Temperatures
- Condenser Leakage

ASHCROFT GAUGE DIVISION
AMERICAN SCHAEFFER & BUDENBERG INSTRUMENT DIVISION

Manning, Maxwell & Moore, Inc.

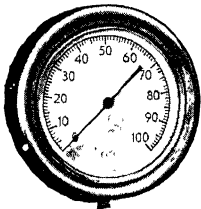
Bridgeport, Conn.—BRANCHES IN PRINCIPAL CITIES

Makers of AMERICAN INDUSTRIAL INSTRUMENTS—Since 1851

Manufacturers of Indicating and Recording Gauges; Gauge Testers; "U" Gauges; Draft Gauges; Indicating and Recording Thermometers; Tachometers; Dial Thermometers; Pressure and Temperature Controllers; Electric Temperature Controllers; Pop Safety and Water Relief Valves; Steam Traps; Absolute Pressure Gauges.

Also manufacturers of Bronze, Cast Steel and Forged Steel Valves, Engine Room Clocks; Barometers; Mercury Column Gauges; Gauge Boards.

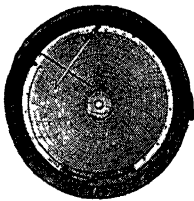
Ashcroft Gauges—Ashcroft Gauges are made in all sizes from $2\frac{1}{2}$ to 12 in., for pressures from 8 oz to 25,000 lb and also for vacuum. Cases are cast-iron or cast brass. The movements are heavy duty and all bearings are Monel Metal. Write for Catalog No. A-59.



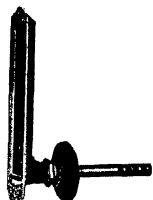
Also Duragauges—accurate to within $\frac{1}{2}$ of 1 per cent. Stainless steel movement. In Phenol Cases in $4\frac{1}{2}$ in., 6 in. and $8\frac{1}{2}$ in. dial sizes

For Mercury Pressure and Vacuum Gauges, "U" Gauges, Draft Gauges and Mercurial Barometers, write for Catalog B-59.

Recording Duragauges—Recording Duragauges are made for all pressures from 15 in. of water to 10,000 lb and for vacuum. They are made in one size only to accommodate a 10 in. chart, having an effective scale width of $3\frac{5}{8}$ in. The case is die cast with a dull black hard-rubber finish and with either bottom or back connection. The pen-arm is made of non-corrosive monel metal and is of the inverted type. Operating instructions are lithographed on the chart plate so that they cannot be lost. Write for Catalog E-59.

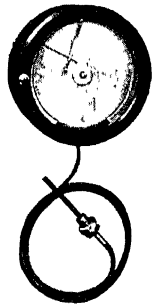


American Air Duct Thermometer—Designed especially for both warm and cold air ducts. Fitted with chromium plated frame, glass front. Furnished with 9-in. or 12-in. scale graduated 0-160 F. Write for Catalog F-59.



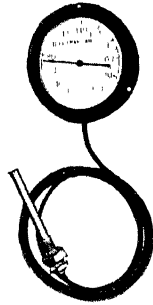
American Recording Thermometers—Made for recording temperatures from minus 40 to plus 1000 F or equivalent C. Very flexible connecting tubing up to 200 ft. One size to accommodate 10 in. chart, with an effective scale width of $3\frac{5}{8}$ in.

Same case as for the American Recording Gauge, so that all instruments are uniform in appearance when mounted on Gauge Boards. Write for Catalog H-59.

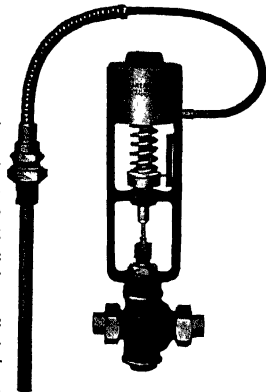


American Dial Thermometers—American Dial Thermometer (mercury-filled) has the accuracy of the standard glass tube thermometer and the reading convenience of a dial face. Entire working mechanism is made of steel, meaning long life.

Six sizes, ranging from $4\frac{1}{2}$ in. to 12 in. diameter dials. Furnished with rigid connection or flexible capillary tubing up to 200 ft. For temperature ranges from minus 40 to plus 1000 F. Write for Catalog G-59.



American Precision Temperature Controllers—Self-operated. For regulating temperatures from 20 to 325 F. For hot water service tanks, water heaters, etc. Size of valve must be specified. Write for R-59 Bulletin.



The Mercoid Corporation

COMPLETE LINE OF AUTOMATIC CONTROLS

Main Office and Factory
4201 BELMONT AVE., CHICAGO, ILL.
Distributors and Jobbers
in all Principal Cities

Branch Offices
NEW YORK, N. Y., 393-7th Avenue
PHILADELPHIA, PA., 3137 N. Broad St.
BOSTON, MASS., 839 Beacon St.

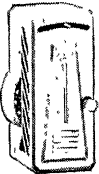
Mercoid Controls are equipped exclusively with Mercoid hermetically sealed mercury switches.



*Mercoid
Switch*

They are not affected by dust, dirt or corrosion and are noted for their dependable performance and long life.

MERCOID SENSATHERMS



Mercoid room thermostats known as Sensatherms operate on a total differential of 1 deg F (plus or minus $\frac{1}{2}$ deg F). Type H is the standard thermostat for heating, etc. Type DNH (illustrated) is a hand wound day-night thermostat for maintaining lowered temperatures for any period up to 12 hours. At a set time in the morning, it automatically reverts back to the day setting. Type HBH is a two-stage thermostat for control of high-low gas or oil burners. Prevents overshooting on stoker systems, etc. Type HH is a dual thermostat for heating and cooling operations.

PRESSURE AND TEMPERATURE LIMIT CONTROLS



These instruments are of proven reliability and long life. The outside double adjustment with calibrated dial is a time saving feature when making adjustments. Available for steam, hot water and warm air.

VISAFLAME

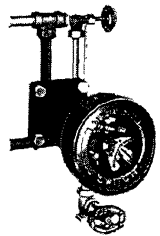
The Mechanical Eye Actuated by Light



A control system for direct burner mounting. It represents a decided improvement in oil burner safety control. Operates direct from the light of the flame instead of from the heat in the stack. Used in conjunction with the K-2-1 panel unit for intermittent burners and the K-2 for constant ignition burners.

COMBINED PRESSURE AND LOW WATER CONTROL

Type DA-131Q prevents firing into dry boilers and guards against building up excess steam pressure. Has quick hook-up fittings designed in accord with the A. S. M. E. Code. Instead of a packing gland, a flexible diaphragm is used which eliminates sticking or erratic operation. Has outside double adjustments. Other types of low water and boiler water feed pump controls available.



OIL BURNER SAFETY AND IGNITION CONTROL

Type JMI provides positive protection against flame or ignition failure on intermittent ignition oil burners. This control insures having ignition circuit closed before every starting operation of burner. Type JM is used for constant ignition burners.



STOKER TIMER CONTROLS

Type TV2 Stok-A-Timer combines a Mercoid Transformer-Relay and a synchronous motor timer mechanism for maintaining the stoker fire during periods when thermostat is not calling for heat. Interval adjustment can be set for $\frac{1}{2}$ hr. or 1 hr. merely by moving a lever. cams required.



No change of

Minneapolis-Honeywell Regulator Company

2711 Fourth Ave., So., Minneapolis, Minn. Cable Address: MINNREG, MINNEAPOLIS

**Electric or Pneumatic Control Systems for
Heating, Ventilating, Air Conditioning**

BROWN INSTRUMENTS for Indicating, Recording, Controlling

Factories: MINNEAPOLIS, MINN., PHILADELPHIA, PA., WABASH, IND., CHICAGO, ILL.

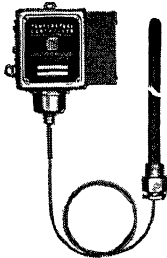
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In Canada: MONTREAL, TORONTO, CALGARY, VANCOUVER, LONDON, WINNIPEG

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AUTOMATIC CONTROLS FOR EVERY APPLICATION

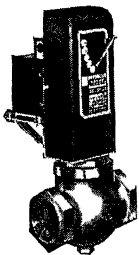


*Electric Duct Type
Temperature
Controller*

Minneapolis-Honeywell manufactures a complete line of electric, pneumatic, and self-contained controls and regulators for every type of heating, ventilating, and air conditioning installation. In addition, the Brown Instrument Division of Minneapolis-Honeywell manufactures a complete line of indicators, recorders, and controllers for Industrial Process applications.

Each of the branch offices of Minneapolis-Honeywell maintains a staff of experienced engineers who are qualified to give unbiased advice on any type of control application and to install and service control equipment of any type. They are prepared to assist in the writing of specifications and to furnish control layouts and cost estimates without charge.

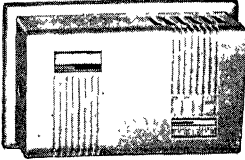
Minneapolis-Honeywell, with 55 years of experience in the control field, is the only company which is prepared to furnish every type of control, whether electric, pneumatic, or self-contained for any type of installation. This eliminates the necessity of purchasing controls from more than one company, which often results in split responsibility and unsatisfactory results.



*"Modutrol Valve"
Electric Control
Valve*

THE MODUTROL SYSTEM OF ELECTRIC CONTROL

The **Modutrol System** designation is applied to any combination of Minneapolis-Honeywell Automatic Electric Controls or Self-contained Automatic Valves used to govern the operation of air conditioning or heating systems other than the small domestic installations. A wide variety of both modulating and two position motors, controllers and valves are available thus making the Modutrol System extremely flexible as to the selection of control equipment to produce the desired results.



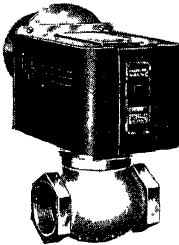
*"Gradustat"
Pneumatic Thermostat*

THE GRADUTROL SYSTEM OF PNEUMATIC CONTROL

The Gradutrol System designation is applied to any combination of Minneapolis-Honeywell Automatic Pneumatic Controls used to govern the operation of air conditioning or heating systems. Such features as infinite positioning with the Gradutrol Relay and accurate graduation of valve and damper motors makes the Gradutrol System a truly remarkable advance in pneumatic control of commercial air conditioning and space heating installations.

COMBINATION ELECTRIC AND PNEUMATIC SYSTEMS

The outstanding advantages of both the electric Modutrol System and pneumatic Gradutrol System of control may be combined in a single installation. Thus maximum flexibility and low installation cost are obtained. Minneapolis-Honeywell can offer either an electric or pneumatic system, or a combination of the two. This is your guarantee of an unprejudiced recommendation.



*"Grad-U-Valve"
Pneumatic Control Valve*

BROWN INSTRUMENTS

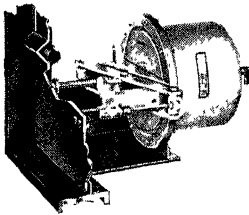
The extent to which air conditioning equipment is being used in office buildings, theatres, stores, industrial buildings, etc., has opened up a wide demand for indicating and recording resistance thermometers because the temperatures throughout these air conditioning systems should be checked periodically in order to obtain the best results at minimum operating cost. To obtain uniform conditions from modern equipment, it is necessary that the engineer in charge of operation have a visual picture of actual conditions.

Brown Resistance thermometers are available for indicating, recording, and controlling service and are applicable to all types of air conditioning and space heating installations.

In addition to Resistance Thermometers, The M-H Brown Instrument Division manufactures:

Thermometers
Hygrometers
Pressure Gauges
Vacuum Gauges
Potentiometer Pyrometers

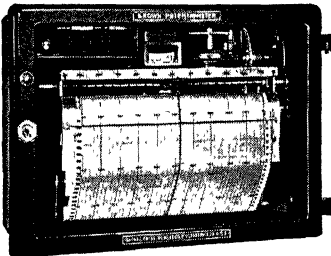
Flow Meters
CO₂ Meters
Tachometers
Liquid Level Gauges
Protectoglo System



*"Grad-U-Motor"
Pneumatic Damper Motor*

RESPONSIBILITY FOR ENTIRE CONTROL SYSTEM

Minneapolis-Honeywell Regulator Co. is equipped to assume the entire responsibility for any control installation, thereby eliminating the difficulties and misunderstandings which division of responsibility may create.



Brown Recording Resistance Thermometer

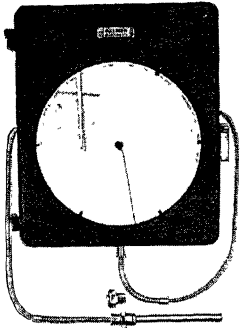
The Palmer Company

Main Plant: 2506 Norwood Ave., Cincinnati (Norwood), Ohio

Canadian Factory: King and George Sts., Toronto

Manufacturers and Originators—"Red-Reading-Mercury" Thermometers

RECORDING THERMOMETERS

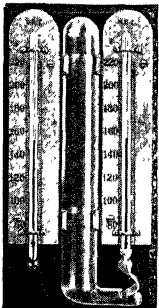
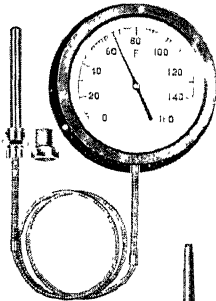


Mercury Actuated. 12 in. die-cast aluminum case. Wrinkle or Satin finish. All parts are rust-proof. Flexible armoured tubing and bulb of stainless-steel. Fittings: Plain, Union, Separable-socket and adjustable or union flange. All ranges up to 1000 F or

550 C. Guaranteed extremely accurate and sensitive. Every part strengthened for long and satisfactory service. Write for Bulletin No. 1800.

DIAL THERMOMETER

Mercury Actuated. 8 in. case. Black rubberized finish. Flexible armoured tubing and bulb of stainless-steel. All parts are rust-proof. Fittings: Plain, Union, Separable-socket and Adjustable or Union flange. All ranges up to 1000 F or 550 C. Guaranteed sensitive and accurate and to give long and satisfactory service. Write for Bulletin No. 1500.



**WALL
HYGROMETER
and SLING
PSYCHROMETER**

Wet and Dry bulb; Mercury tube, with RED column. Chart furnished. Guaranteed sensitive and accurate. Send for Bulletin No. 500.



"RED-READING-MERCURY"



Industrial Thermometers—These mercury tubes will show a bright RED color, visible at a great distance. The color is reflected and cannot fade. (Patented by Palmer). Thoroughly annealed and guaranteed permanently accurate. Costs no more. STRAIGHT, ANGLE, SIDE - ANGLE, RECLINING AND INCLINING Case, OBLIQUE STEM, etc. 7, 9 and 12 in. case, with or without glass front Standard 3½ in. stem and longer lengths. Fittings: Fixed Thread, Union, Separable-socket and Adjustable or Union Flange. All ranges up to 750 F or 400 C. For ranges up to 1000 F or 550 C,

with plain mercury tube, borosilicate glass. Write for Catalog No. 200-F.

REPAIRS—To all makes of Industrial Mercury Thermometers, furnishing "Red-Reading-Mercury" tube, at no extra cost and replacing all worn or broken parts, making the thermometer as good as new. Guaranteed accurate. A trial order will convince you.

LABORATORY THERMOMETERS

Glass engraved mercury tube; show bright RED column . . . so easy to see. With or without metal armour; Round

or Lens glass; ranges to 750 F. or 400 C Plain mercury tube borosilicate glass on ranges 1000 F. or 550 C. Correctly annealed and guaranteed accurate

POCKET THERMOMETERS . . . for quick tests. Reliable and accurate. With RED column.

— 20 + 120 F.
0 + 220 F.

Write for Catalog No. 300-D.



Penn Electric Switch Co.

Goshen, Indiana

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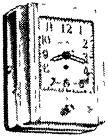
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IN CANADA—POWERLITE DEVICES LTD., PENN ELECTRIC SWITCH DIV., TORONTO, ONT.

Distributors and Jobbers in All Principal Cities

Automatic Controls for Heating, Refrigeration, Air Conditioning, Pumps, Air Compressors



Tem-Clock



Temtrols

Temperature and Humidity Controls

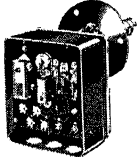
For control of temperatures and humidity in heating, cooling and air conditioning equipment.



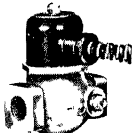
Humidstat



*Heavy Duty
Thermostats*



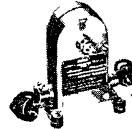
*Oil Burner
Stack Switches*



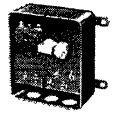
*Solenoid
Gas Valves*

Combustion Controls for all Fuels

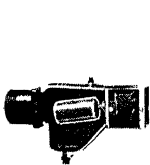
For automatic fuel burning equipment, and for stack combustion control.



*Damper
Motors*



*Sloker
Timer Relays*



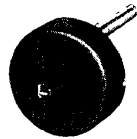
*Cut-offs and
Feeders*



*Steam Pressure
Controls*

Boiler and Furnace Controls

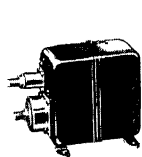
For feedwater, steam pressure, liquids and warm air.



*Liquid Immersion
Temperature Controls*



*Warm Air
Bonnet Controls*



*Refrigeration
Compressor
Controls*



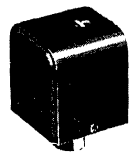
*Water and
Refrigerant
Solenoids*

Many Others

For control of refrigerants, water and air; and for pumps and compressors.



Water Valves



*Pump and Air
Compressor
Controls*

Write for catalog on Penn Controls to cover your particular applications, or 'phone the nearest Penn office or repre-

sentative. Penn engineers always are available for consultation on control problems, without obligation, of course.

Penn control engineers have simplified design and production problems for others! Let them assist you.

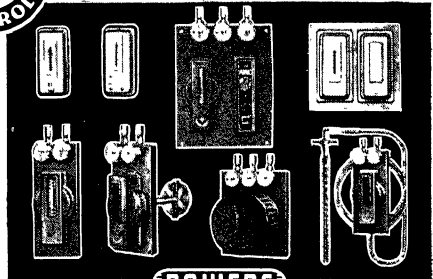
THE POWERS REGULATOR CO.

Over 50 Years of Temperature and Humidity Control—Offices in 47 Cities

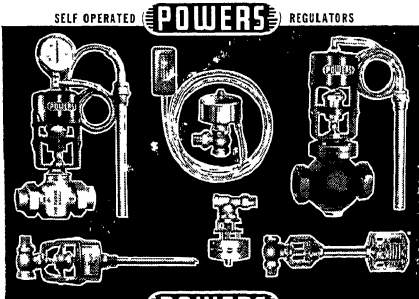
NEW YORK CITY, 231 East 46th St.—CHICAGO, 2719 Greenview Ave.—LOS ANGELES, 1808 W. Eighth St.
BOSTON, 125 St. Botolph St.—PHILADELPHIA, 2240 N. Broad St.—GREENSBORO, Jefferson-Standard Bldg.
ATLANTA, Bona Allen Bldg.—DETROIT, Boulevard Bldg.—CINCINNATI, American Bldg.—NEW ORLEANS, Balter Bldg.



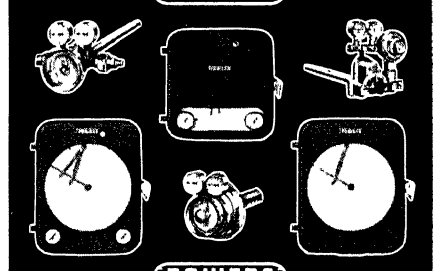
A very complete line of compressed air operated and self-operating temperature, humidity and air flow controls for automatically regulating heating, cooling, ventilating and air conditioning systems and industrial processes.



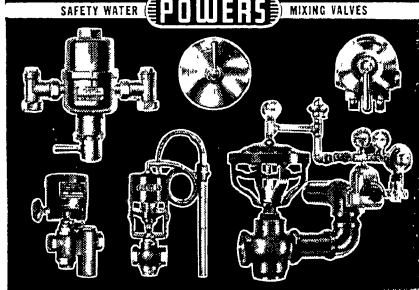
AIR OPERATED **POWERS** CONTROLS



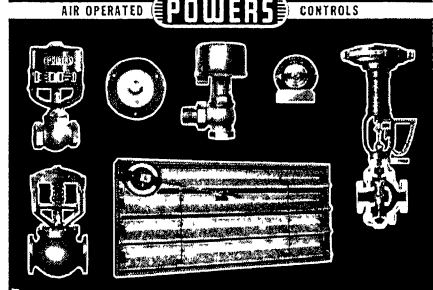
SELF OPERATED **POWERS** REGULATORS



AIR OPERATED **POWERS** CONTROLS



SAFETY WATER **POWERS** MIXING VALVES



Over 50 years of experience in furnishing and installing temperature and humidity control for every conceivable purpose in all types of buildings have given us a wealth of experience from which you can draw in selecting the proper type of control for any purpose.

Catalogs and Bulletins describing any or all of our products furnished upon request. Phone or write our nearest office. See your phone directory.

Spence Engineering Company, Inc.

28 Grant Street, Walden, N. Y.

SPENCE METAL DIAPHRAGM "DEAD END" REGULATORS Advantages of Spence Regulators

Dead-end Shutoff—Spence Regulators are guaranteed to hold a dead-end

Single Seat—Spence design makes possible a balanced single seat even in large sizes.

Metal Diaphragms—Under normal conditions never require replacement.

Accurate Regulation—Regardless of fluctuations in either load or initial pressure.

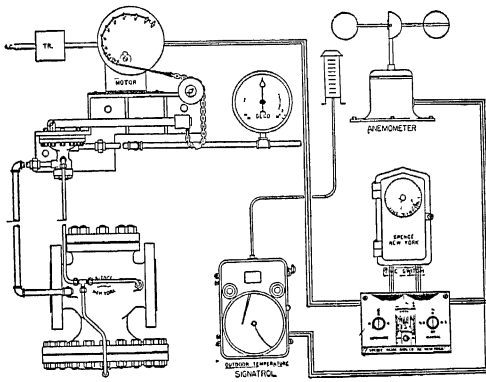
SECO Metal—Guaranteed to resist the wire-drawing action of steam.

Interchangeable Pilots—Any type of pilot will fit any size main valve.

Accessibility—Pilot is connected to main valve with unions.

No Stuffing Boxes—All main valves and most pilots are packless.

Spence Weather Compensator and Orifice Zone Control System

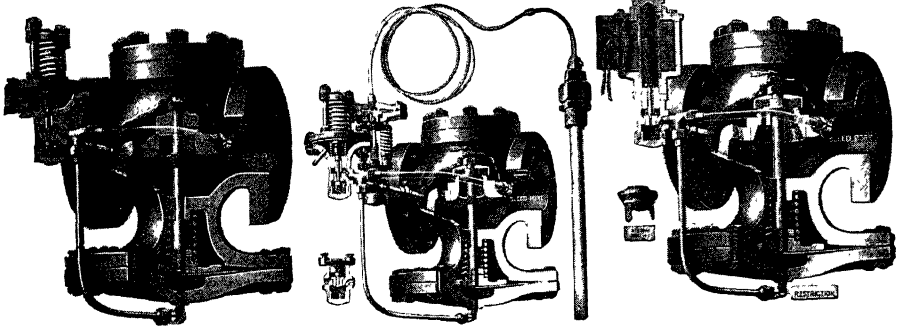


This simple, dependable Control, when installed on a properly designed orificed heating system, will show a substantial degree-day steam saving, at a low maintenance cost.

The delivery pressure of the Regulator is automatically adjusted in direct proportion to the building heat losses. In other words, as the losses become greater, steam pressure on the system is automatically increased.

Any number of zones can be controlled by one automatic Signatrol, automatic Wind Loss Compensator (Anemometer) Time Switch and Master Control Panel equipped with Manual and Automatic Dials for each zone. In this way each zone

can be set individually and at the same time be under the Master Control.



**Pressure Regulator—
Type ED**

Designed to regulate a steady or varying initial pressure so as to maintain a constant, adjustable, delivery pressure. Applicable to heating systems, power plant operations, or manufacturing processes.

**Combined Temperature
and Pressure Regulator
—Type ETD**

Self-contained, pilot operated, dead-end. Designed to control flow of fluid to a heating or cooling element, so as to maintain a constant, adjustable temperature, and protect the element against excessive pressure.

**Electrically Operated
Valve—Type EM**

Can be opened or closed independently by an electrical switch.

Type ET—Same as ETD except pressure control is omitted.

Order a SPENCE Regulator for 40 days' free trial.

Fall-O-Matic Universal Pipe Intersection Cutter.

Taylor Instrument Companies

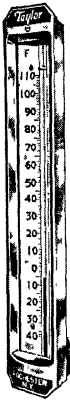
Rochester, N. Y., U. S. A.

IN CANADA—TAYLOR INSTRUMENT COMPANIES OF CANADA, LTD., TORONTO

NEW YORK	LOS ANGELES	ST. LOUIS	DETROIT
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BOSTON	CLEVELAND	SAN FRANCISCO	MINNEAPOLIS
PHILADELPHIA		TULSA	WILMINGTON

Manufacturing Distributors in Great Britain, Short & Mason, Ltd. London

Taylor Instruments for Indicating, Recording and Controlling Temperature, Pressure, Humidity, Flow and Liquid Level



Taylor Industrial Thermometers—with new "BINOC" Tubing—Includes many styles and scale ranges with bulbs for every application. These thermometers contain a new and radical development of tremendous importance—"BINOC" Tubing. This newly designed and optically correct glass tubing assures an ease of reading that has been generally lacking in industrial thermometers. "BINOC" Tubing more than doubles the angle of vision within which readings can be made.

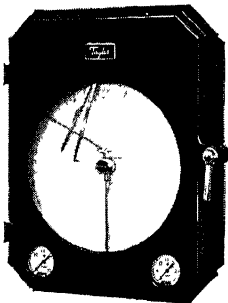
Because of the patented Triple-lens construction its broad mercury column can be read easily and accurately with both eyes. Bore reflection is absent.

Taylor "BINOC" Pocket Test Thermometer—Ideal for frequent testing of important temperatures. Taylor patented "BINOC" Tubing eliminates juggling and guesswork. High accuracy—Easier to Read.



The New Taylor "Fulscope" Recording Controller—An air-operated controller that gives practically any character of process control regardless of time lag in apparatus.

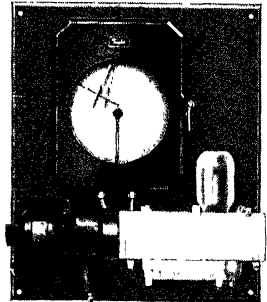
Available for controlling temperature, pressure, humidity, rate of flow, liquid level. Where extreme load changes or badly balanced operating conditions exist, precision control can be maintained by the automatic reset feature. For applications where a record is not needed, Taylor supplies an Indicating "Fulscope" Controller.



Taylor Biram's Anemometer—Ideal for measuring air velocities with the fan revolutions indicated on the dial. Various models for a wide range of air speeds and registration limits.

Taylor Recording Hygrometer—Records both wet- and dry-bulb temperatures on the same chart in different colored inks, making comparison very easy.

Type shown has motor-driven fan for conditioned rooms or passages where circulation is poor. Furnished without fan for installations where circulation across bulb is good.



Taylor Sling Psychrometer—The advantage of this form of Wet- and Dry-Bulb Hygrometer over the stationary form is the facility with which tests can be made and the accuracy of the readings obtainable, as the whirling bulbs are subjected to perfect circulation. Two accurate etched stem thermometers are mounted on a die-cast frame, with the bulb of one covered with a wick to be moistened.

These thermometers have scales of 20 to 120 degree F, graduated in 1/2-deg divisions. A copper case protects the tubes when not in use.

Taylor also offers a complete line of the famous Taylor Recording and Dial Thermometers, Self-Acting and Type "P" Controllers, the 10-BG Hygrometer and many types of Humidiguides.

UNITED STATES GAUGE COMPANY



Indicating and Recording Pressure Gauges

44 BEAVER STREET • NEW YORK

FACTORY SELLERSVILLE PENNSYLVANIA
BRANCHES NEW YORK CHICAGO PHILADELPHIA
BOSTON CLEVELAND DETROIT • ST. LOUIS
HOUSTON SEATTLE LOS ANGELES MONTREAL

U. S. GAUGES—U. S. Gauges are made in all standard sizes from 2 in. to 12 in. dial inclusive for pressures up to 50,000 lb and for vacuum. Gauges may be supplied with cast-iron, cast-brass, drawn steel, or drawn brass cases for wall mounting or flush mounting. For severe service requirements we can supply long wearing hardened steel movements or bushed movements.

For service on Steam Heating Systems the following gauges may be supplied—

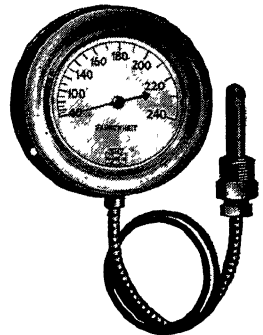
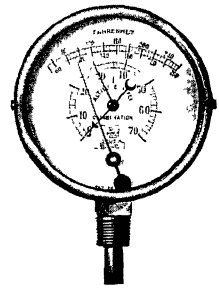
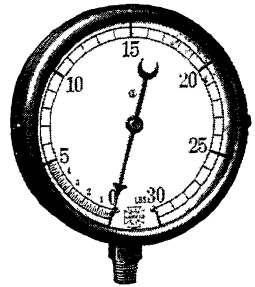
Steam Gauges . . . Compound Pressure and Vacuum Gauges
. . . Retard Gauges . . . Compound Retard Gauges
. . . Steam Gauges with Internal Siphons

For service on Hot Water Heating Systems the following instruments and gauges may be supplied—

Altitude Gauges . . . Tank-in-Basement Gauges . . .
Altitude and Pressure Gauges . . . Combination Altitude
Gauges, and (a) Bimetal Thermometers, (b) Glass Tube
Thermometers, (c) Vapor Tension Distance Type Ther-
mometers . . . Glass Tube Hot Water Thermometers.

U. S. RECORDING GAUGES—U. S. Recording Gauges are supplied in 8½ in., 10 in. and 12 in. sizes for pressures up to 50,000 lb and for vacuum. These Recording Gauges can be supplied with either cast-iron or cast-brass cases for wall mounting or flush mounting. Pen arms are made of non-corrosive metal. Especially designed clock movements are used. Charts can be furnished for customary time periods.

U. S. DIAL THERMOMETERS—U. S. Dial Thermometers are of the vapor tension type with open scale reading in the center and upper portion of the scale, or of the glass filled type with even scale reading. Cases may be cast-iron, cast-brass, drawn steel, or drawn brass for either wall or flush mounting. Supplied in all standard sizes from 2 in. to 12 in. dial inclusive, for temperature ranges from minus 40 deg F to 800 deg F. Furnished with rigid connection bulb or with bulb at end of flexible capillary tubing up to 100 ft long.



White-Rodgers Electric Company

1293 Cass Avenue, St. Louis, Mo.

NEW YORK CITY
SAN ANTONIO

CHICAGO

PHILADELPHIA

CLEVELAND

COLUMBUS

ATLANTA

LOS ANGELES

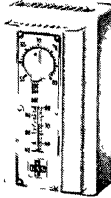
SAN FRANCISCO

SEATTLE

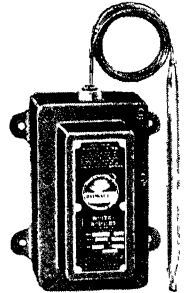
Distributors in Principal Cities



Line voltage Thermostat for Unit Heater and Air-Conditioning Installations.



Low Voltage Room Thermostat—anticipating type.

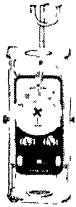


Explosion-Proof Thermostat for hazardous locations—remote type.

PUT "HYDRAULIC ACTION" TO WORK FOR YOU

The powerful, uniform expansion and contraction of a solid liquid charge against a stainless steel diaphragm, combined with the mechanical simplicity of White-Rodgers Controls contributes these important features to the field of automatic temperature control:

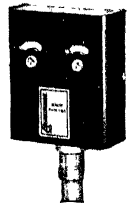
1. *Visible, uniformly calibrated dials.*
2. *Easily set differential adjustor.*
3. *Fast acting thermal elements.*
4. *Combination controls with independently adjustable switches.*



Single speed fan control—cover removed showing visible dial.

High capacity switch—the tremendous force available with Hydraulic Action has resulted in a sturdy switch with Underwriters' approved rating of $1\frac{1}{2}$ hp 240 v AC, 1 hp 120 v AC.

Take advantage of Hydraulic Action on your next installation. Specify White-Rodgers Controls. The latest condensed control catalog is awaiting your request. Write for it today!



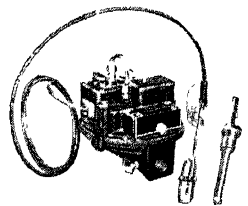
Dual Immersion Control—Limit-Circulator or Summer-Winter service



Steam Pressure Control—for safety limit service.



Solenoid Gas Valve—High plunger torque and silent operation.



Diaphragm Gas Valve with puff bleed and built-in mechanical limit control.

HEATING SYSTEMS

Steam and hot water heating systems with their many parts and accessories are classified according to their specific type of design and the service required. These systems and their component parts include:

HEATING SYSTEMS (p. 1021-1092)

Combinations of parts forming steam vapor and vacuum systems and hot water systems.

Technical data on steam heating systems are contained in Chapter 14; hot water systems in Chapter 16. Other references to heating systems will be found in the Index to the Technical Data Section.

BOILERS (p. 1042-1066)

Water tube, fire tube and firebox types; cast iron and steel construction; for coal, coke, gas or oil firing.

Technical data on heating boilers are given in Chapter 12.

In connection with steam and hot water heating systems various types of radiators and convectors are required. Complete manufacturers references will be found in the Index to Modern Equipment—pages 1137-1160.

Technical data is contained in Chapter 13.

BURNERS (p. 1067-1071)

Automatic fuel burning equipment suitable for use as an integral part of heating boilers and furnaces, and also for conversion of hand-fired heaters to automatic operation. Gas burners, oil burners, stokers.

Technical data are given in Chapter 10.

PUMPS (p. 1072-1075)

For use in conjunction with heating systems, and other purposes in heating, ventilating and air conditioning service; and for handling air, gases, ammonia, brine and other refrigerants.

References to technical data on pumps will be found in the Index to the Technical Data Section.

SPECIALTIES (p. 1076-1088)

Feed water devices, pressure and draft regulators, combustion controls, strainers, traps, valves, etc.—all essential for efficient operation of heating equipment.

References to technical data on heating specialties may be found in the Index to the Technical Data Section, each indexed under its respective title.

PIPE AND FITTINGS (p. 1089-1092)

Iron, steel, wrought iron, copper, brass—seamless or welded.

Technical data will be found in Chapter 18.

Manufacturer's products shown in this division are designed for specific applications. Consult the Index to Modern Equipment for additional products of these manufacturers.

Barnes & Jones

INCORPORATED

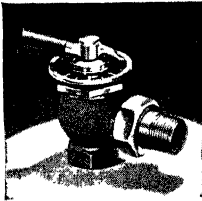
129 Brookside Avenue

New York Office: 101 Park Avenue

Boston, Mass.

Barnes & Jones Vapor and Vacuum Systems of Steam Heating; Modulation Valves; Adjustable-Orifice Radiator Valves; Packless Quick-Opening Radiator Valves; Thermostatic Radiator Traps; Thermostatic Trap Replacement Units; Condensators (Boiler Return Traps); Float and Thermostatic Traps; Strainers; Damper Regulators; Gages; Systems of Zone Control for Steam Heating. Complete Catalog on Request

Modulation Valves, Type K—Packless Quick Opening Valves, Type F



Types K and F Valves have non-tarnishable indicating dial, non-rising stem, renewable disc seat. Tail piece extra heavy. Extra long to facilitate installation. Three models: lever handle, wheel handle, lock shield. Type F Valve furnished with wheel handle only.

Type K Valve

Size	1/2"	3/4"	1"	1 1/4"
Cap. Sq Ft Rad.*	30	60	100	180

Type F Valve

Size ...	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"
Cap. Sq Ft Rad *	30	60	100	180	270	400

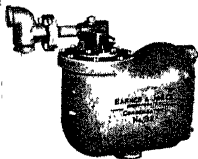
*Based on 2 oz pressure differential.

Adjustable Orifice Valves, Type H



May be adjusted for different capacities after installation. At all times provides indication of the adjustment. Operation is quiet. Unauthorized tampering with adjustment is virtually impossible.

Condensators

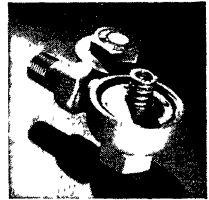


For returning water of condensation to boiler from open return line systems independently of boiler pressure, without change in operating conditions, air binding, or admitting steam to the return side.

No.	31	32	33	34	35	36
Cap. Sq Ft Rad *....	700	1600	3500	6000	10,000	16,000

Thermostatic Radiator Traps

Sturdily made to precision standards. Sensitive in operation. Provide instant discharge of air and water, prevents passage of steam. Contains unique Cage Type Thermostatic Unit, which carries its own thermostatic element, valve piece and valve seat, factory calibrated and locked in correct adjustment.

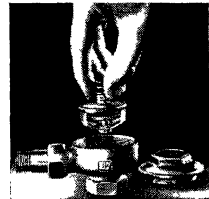


Trap No.	120	12	123	124	134	13	14
Inlet Tapping	1/2"	1/2"	1/2"	1/2"	3/4"	3/4"	1"
Outlet Tapping	1/2"	3/4"	1/2"	3/4"	3/4"	3/4"	1"
Cap. Sq Ft Rad *	200	200	400	400	400	700	1200

*Based on 1 1/2 lb pressure differential.

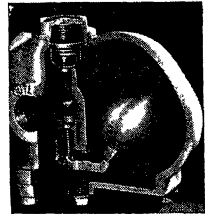
Thermostatic Radiator Cage Replacement Units

Offer complete and reliable trap renewal in practically every make of thermostatic trap. You simply (1) remove the old cover and unit, (2) insert the new Barnes & Jones Cage Unit, (3) replace the cover, and the old trap will operate with its original efficiency.



Float and Thermostatic Traps

Handle large and sudden condensation loads. Large air and water capacity. Large float assures instant opening of the discharge valve. Cage Type Thermostatic Unit assures quick elimination of air.



Trap No.	41	42	43	43A	44B	45B
Inlet Tapping	3/4"	1"	1 1/4"	1 1/2"	1 1/2"	2"
Outlet Tapping	3/4"	1"	1 1/4"	1 1/2"	1 1/2"	2"
Cap. Lb. Water per Hour*	200	700	1200	1200	2400	5000

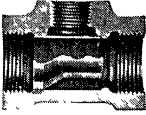
*Based on 2 lb pressure differential.

Bell and Gossett Company

Morton Grove, Illinois
(Suburb of Chicago)

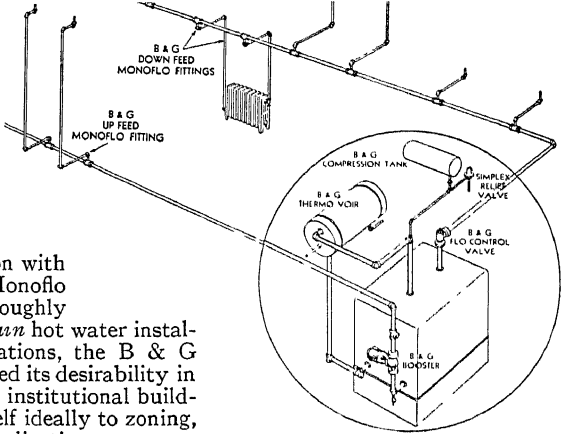
HOT WATER SYSTEMS AND SPECIALTIES

B & G MONOFLO HEATING SYSTEMS

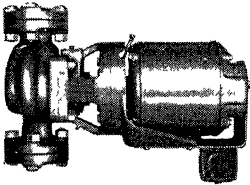


B & G Monoflo Fitting

A genuine advance in controlled and economical heating is offered by the B & G Monoflo System. In conjunction with forced circulation, the B & G Monoflo Fitting makes possible a thoroughly practical, well balanced *single main* hot water installation. In over 100,000 installations, the B & G Monoflo System has demonstrated its desirability in homes, apartments, factories and institutional buildings. The equipment lends itself ideally to zoning, yet is exceedingly simple in application.



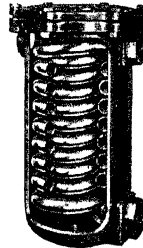
EQUIPMENT REQUIRED



B & G Booster

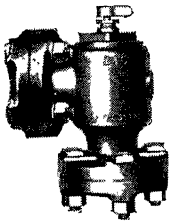
An electrically-driven centrifugal pump, which mechanically circulates hot water through the system — distinguished by genuine oil

lubrication, patented water-tight seal and precision manufacture throughout.



B & G Indirect Water Heater

Any one of five B & G Heater types can be installed to furnish year around domestic hot water at smallest possible cost.



B & G Angle Flo-Control Valve

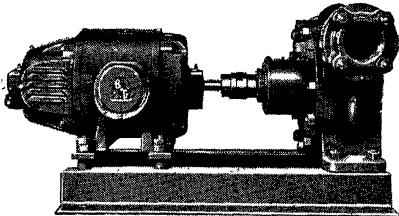
This valve, installed in the main, controls circulation of hot water to radiators, permitting summer operation of the Indirect Water Heater. It also helps maintain a uniform room temperature during the heating season

B & G Motorized Valves



B & G Motorized Valves are ideal for controlling boiler water flow through the individual circuits of zoned heating systems.

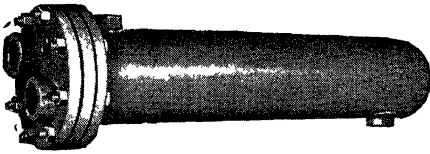
B & G Universal Pump



THE B & G UNIVERSAL PUMP is designed primarily for large warm water heating systems in apartment buildings, office buildings, factories, schools, etc. The installation can be operated as one large single zone or divided into several zones by controlling the circulation of the pumped water through each circuit with a B & G Motorized Valve, operated by a zone thermostat; the pump being either operated continuously or until all valves are in the closed position.

See the B & G Handbook for Complete Engineering Data

HEAT TRANSFER EQUIPMENT

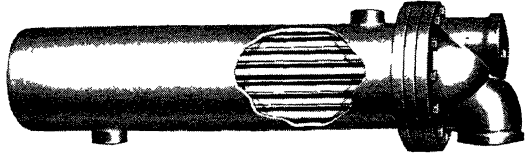


B & G Steel Tube Indirect Water Heaters

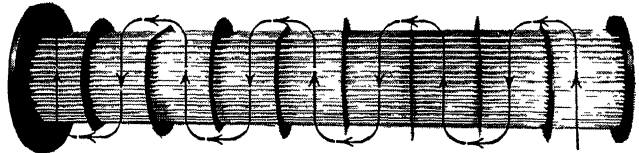
These steel tube heaters are offered as equally efficient substitutes for copper tube units now prohibited by war conditions. Available in a wide range of capacities for both tank and tankless operation.

B & G Steam Convertors

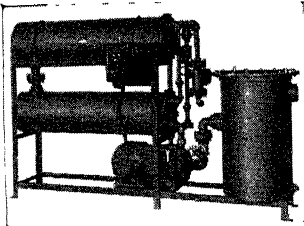
Extensively used where steam is required in the factory for power or process work but where the benefits of *mechanically circulated hot water* are desired for the heating system. Steam is passed through the convertor shell, thereby heating water circulated through the tubing. The water is then pumped through the heating system.



Typical Tube Bundle as Used in B & G Heat Transfer Unit



The Bell & Gossett Company offers a complete line of heat transfer equipment for either heating or cooling liquids and gases. Illustration above shows a tube bundle with baffles directing the water flow so as to obtain maximum cooling effect.



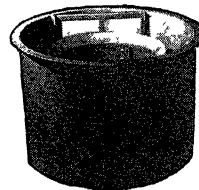
B & G Rapid Oil Coolers

B & G Oil Coolers utilize city water to cool quenching oil and maintain the quench tank constantly at the desired degree. Furnished either as a separate unit or as part of a complete B & G Oil Cooling System, including Quench Tank, Pump, Temperature Regulator, Motorized and Relief Valves, Electrical Controls, Strainer, etc.



B & G Diesel Engine Coolers

Heated water from engine jacket is circulated through tubes of unit and is cooled by cold water circulating through the shell. Eliminates corrosion and deposits within the engine which occur unless the same cooling water is used over and over.

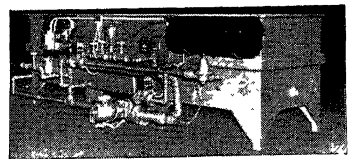


B & G Quench Tanks

It is important that the quench tank be fitted to the product. B & G services, therefore, include the designing and manufacture of quench tanks to suit your specific requirements. Tanks can be constructed to automatically lift out the quenched pieces after the proper time interval.

B & G Wash Tanks

For industrial processes where washing is necessary, B & G builds wash tanks to exactly meet the requirements. Illustration shows a three compartment tank especially designed for washing castings in a large defense plant.



Write for engineering data on B & G Heat Transfer Equipment

C. A. Dunham Company

Administrative and General Offices

450 E. Ohio Street, Chicago, Ill.

Factories: MARSHALLTOWN, IOWA; MICHIGAN CITY, IND; TORONTO, CANADA; LONDON, ENGLAND
TORONTO, 1523 DAVENPORT ROAD, LONDON, MORDEN ROAD, S.W.19

THE DUNHAM DIFFERENTIAL HEATING SYSTEM

The Dunham Differential Heating System, circulating sub-atmospheric steam, maintains desirable temperatures throughout a building by automatic control of both steam temperature and steam volume.

The system is a simple two-pipe system in which all the essentials of circulation, distribution and control are co-ordinated. Control of the temperature of the steam is accomplished by controlling the pressure or vacuum of the steam in the supply piping and radiators to balance exactly the heat input with building-heat-loss.

THE DUNHAM "Victory Line"

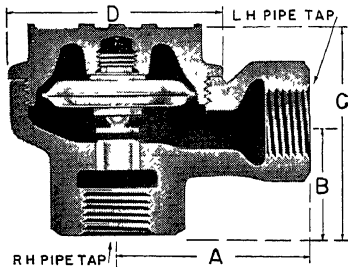
VAPOR AND VACUUM HEATING SPECIALTIES

DUNHAM "VICTORY" RADIATOR TRAP

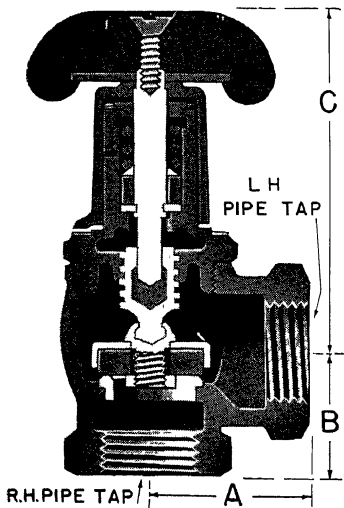
For Operating Pressures Up to 15 Lbs. Gage

Cast iron body and cap. Thermostatic element is phosphor bronze. Valve and valve seat are cuprous alloys. Thermostatic elements are interchangeable in covers without gages. "Victory Line" covers and disc assemblies are interchangeable with standard traps.

Connections are female left-hand threaded inlet and female right-hand threaded outlet.



Type No	Size In.	Patt. No.	Tap- ping In	Cap Sq Ft EDR	Net Wgt. Lbs	Dimensions in Inches			
						A	B	C	D
V1A	1/2	AP	1/2	200	1 1/2	2 1/4	1 1/4	2 3/32	2 7/16
V2B	3/4	AP	3/4	400	2 3/8	2 3/4	1 3/8	2 5/8	3 1/16
V3A	3/4	AP	3/4	700	2 3/8	2 3/4	1 3/8	2 5/8	3 1/16

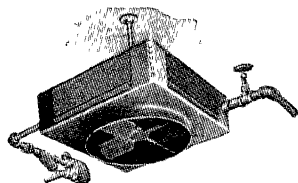


DUNHAM "VICTORY" RADIATOR VALVE (SPRING PACKED)

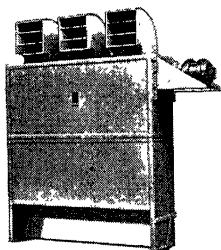
Non-rising handle and low bonnet. The body and bonnet are cast iron, handle is non-breakable, heat resisting composition. Other construction features: Quick opening with less than one turn of handle; heat-resisting graphited asbestos ring with metal core. Held under compression by heavy coil spring to maintain tight seal around valve stem; ball joint insures perfect seating when valve is closed on rounded valve seat; high quality renewable composition disc.

Made in 3/4 and 1-in. sizes angle pattern only with tapped right-hand female inlet, left-hand female outlet

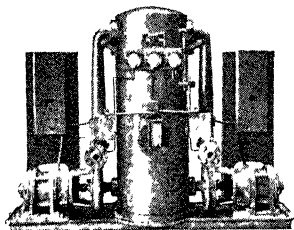
Type No.	Size Inches	Dimensions in Inches			Net Weight in Lbs
		A	B	C	
V740	3/4	1 5/8	1 1/4	3 3/32	1 3/4
V740	1	1 7/8	1 5/16	3 17/32	2 3/8



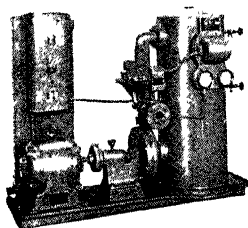
Type C



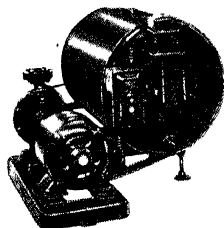
Type R



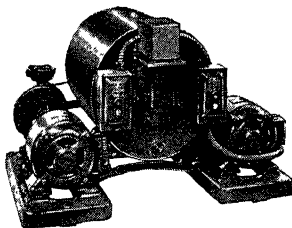
Type VRD



Type DV

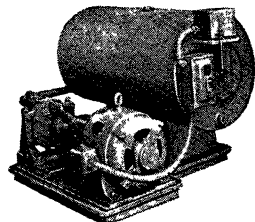


Type CH, Model B, Single



Type CH, Model B, Duplex

Type CHH, Model B Similar Construction to CH Model B
Available in Both Single and Duplex



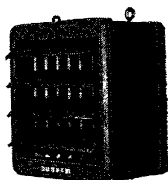
Type CH, Model A
Available in Both Single
and Duplex

DUNHAM UNIT HEATERS

Type C—A specially designed unit heater for industrial and commercial applications. Designed for discharging large volumes of heated air downward to working levels, distributing heat evenly over large areas. Built in various sizes up to 2000 sq ft EDR. Four types of diffusers.

Type R—Blower type unit for industrial and commercial applications. Available in standard sizes, each with various combinations of Btu and cfm output. Floor, wall and suspended types, with and without by-pass or mixing dampers. All sizes and types either direct connected or belt drive.

Type V—Horizontal propeller fan type. Built in various sizes up to 1200 sq ft EDR.



Type V

DUNHAM PUMPS

Tested and Rated with A.S.H.V.E. Code and Code of Vacuum Return Line Heating Pump Manufacturers' Section of Hydraulic Institute.

Vacuum Pumps

Type VRD—Capable of maintaining whole systems under vacuums as high as 25 in. Built in 9 sizes. Capacities 2500 to 65,000 sq ft EDR.

Type VR—Meets all code tests for air and simultaneous air and water handling capacities. No moving parts or close clearances in exhaustor unit. Built in 11 sizes. Capacities 2500 to 150,000 sq ft EDR.

Condensation Pumps

Pump and motor assembled on rigid cast iron base. Bronze fitted centrifugal pump has non-corrosive shaft. Enclosed type Impeller. Liberal size ball bearings.

Type CH—Model B, Single and Duplex—66 sizes of varying capacities and discharge pressures. Capacities 2000 to 50,000 sq ft EDR; 60 cycle d.c. or a.c. 1750 rpm, 25 or 50 cycle a.c., 1450 rpm.

Type CHH—Model B, Single and Duplex—49 sizes of varying capacities and discharge pressures. Capacities 2000 to 50,000 sq ft EDR; 60 cycle d.c. or a.c. 3450 rpm; 25 or 50 cycle a.c., 2850 rpm.

OTHER "VICTORY" LINE SPECIALTIES

Float and Thermostatic Traps 8 sizes, 800 sq ft to 20,000 sq ft. **Closed Float Traps** 8 sizes, 800 sq ft to 20,000 sq ft. **High Pressure Traps** (Inverted Bucket) 1/2 in. and 3/4 in. sizes, up to 150 lb. **Return Traps** 5 sizes, 1500 sq ft to 13,000 sq ft. **Pressure Reducing Valves** Single seated (Type 340) 3/4 in. to 3 in. Double seated (Type 300) 1 1/2 in. to 10 in. Standard Flanged. **Strainers** 1/2 in. to 2 in.

GRINNELL COMPANY^{INC}

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

Executive Offices: Providence, R. I.

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OSHAWA, ONT (Foundry)

PRODUCTS AND SERVICES—

Complete Service on materials to Specification on Power Plant Piping, Industrial Piping, and Industrial Heating Systems; Prefabricated Piping including Pipe Cutting and Threading, Pipe Bends, Welded Headers, Welded and Welding Fittings, Lap Joints and the Grinnell line of products for Super Power.

Grinnell Equiflo Valves for forced hot water heating systems; Grinnell Adjustable Pipe Hangers and Supports; Grinnell Cast Iron and Malleable Iron Pipe Fittings; Grinnell Malleable Iron Unions; Grinnell Welding Fittings; Thermoflex Traps and Heating Specialties.

Also Humidifying Systems; Piping for acids and other special materials.

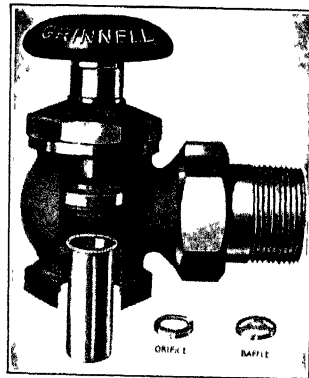
Malleable Iron, Brass, Bronze and other Castings; Brass, Cast Iron, Wrought Iron and Steel Pipe; Seamless Steel Tubing in Iron Pipe Sizes.

Valves: Check, Globe, Pressure Reducing and Regulating, Quick Opening, Safety and Y.

Automatic Sprinkler Systems; Stand Pipes; Underground Supply Mains; Hydrants; Fire Pumps; Pressure and Gravity Tanks.

Grinnell Equiflo Valves

For Forced Hot Water Heating



Equiflo Valve

The designing of forced circulation hot water heating systems is so simplified by the Grinnell Equiflo Valve that they can be laid out and installed as easily as vapor or steam systems. This valve consists of a regular type packless radiator valve with a cartridge or tube made up of a series of orifices and baffles capable of setting up any required frictional resistance. This method of establishing any desired resistance does away with elaborate calculation of pipe sizes. Grinnell guarantees perfectly balanced circulation to each and every radiator where these valves are installed throughout the system.

Equiflo Data Book sent to interested parties.

For Data On Thermoflex Traps and Heating Specialties, see page 1081

GRINNELL ADJUSTABLE PIPE HANGERS AND SUPPORTS

One of the chief advantages of Grinnell Adjustable Hangers is that they permit adjustment of pipe lines after installation, thus obviating the necessity of turnbuckles or the removal of hangers. Their time and trouble-saving qualities during installation are equally exceptional. Below are shown a few Grinnell Hangers and Supports of particular interest to heating engineers. Send for Hanger Catalogue showing complete line.

Adjustable Swivel Rings (Patented)



Fig. No. 101
Solid Ring

These Malleable Iron Adjustable Swivel Rings can be used with Coach Screw Rod or Machine Threaded Rod in connection with practically any type of Ceiling Flange, Expansion Case, Insert, etc.

Adjustment of at least $1\frac{1}{2}$ in. is secured by turning Swivel Shank. Swivel Shank automatically locks, preventing loosening due to vibration in the pipe line.

The Split Ring permits adjustment either before or after Ring is closed. A wedge type pin is loosely but inseparably cast into the hinged section for fastening this section after pipe is in place.



Fig. No. 104
Split Ring

Adjustable Swivel Pipe Rolls (Patented)

An adjustable type of pipe roll using a single hanger rod. Swivel Shank allows vertical adjustment and automatically locks, preventing loosening from vibration.

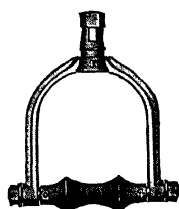


Fig. No. 174
Swivel Pipe Roll

CB-Universal Concrete Inserts (Patented)

Made of air furnace malleable iron, in one body size, to take a special removable nut, tapped for $\frac{3}{8}$ in., $\frac{1}{2}$ in., $\frac{5}{8}$ in. or $\frac{3}{4}$ in. rod as required. Nuts automatically lock by means of V-type teeth on both insert and nuts.

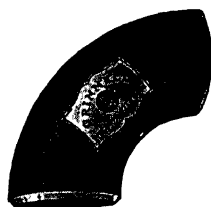


Fig. No. 282
CB-Universal Insert

GRINNELL WELDING FITTINGS

Grinnell Welding Fittings are made from Seamless Steel Pipe or tubing and possess the same physical characteristics as standard, extra strong and o.d. steel pipe or seamless steel pipe of comparable size. They can be used under the same conditions, pressures and temperatures as the pipe itself.

All Grinnell Welding Fittings have welding faces for all plain circumferential butt welds scarfed or beveled as follows: For wall thicknesses $\frac{3}{16}$ to $\frac{3}{4}$ inch inclusive, $37\frac{1}{2}$ deg. $\pm 2\frac{1}{2}$ deg., straight bevel. Angles of bevel other than $37\frac{1}{2}$ deg. can be furnished on special order.



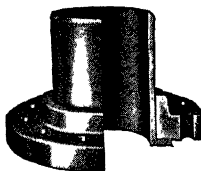
90° Elbow, Long Turn



Welding Outlet



Welding Tee



Lap-Joint Stub End with
Lap Flange attached



Threaded Outlet

Hoffman Specialty Co., Inc.

General Office and Factory

1001 York Street, Indianapolis, Ind.

Sales Representatives in Principal Cities

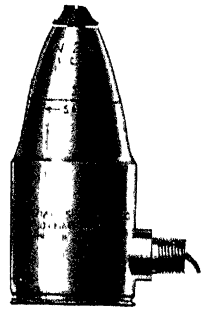
Manufacturers of Adjustable Port Radiator Venting Valves, Quick Vents and Air Eliminators for One and Two Pipe Steam and Vacuum Systems; Hoffman Supply Valves, Traps and Basement Specialties for Controlled Heat Systems, Air Conditioner Hoffman-Economy Vacuum and Condensation Pumps, and Hot Water Controlled Heat Equipment.

AIR VALVES

The Nos. 1A and 40 are used for venting radiators on One and Two Pipe oil or gas automatic fired Steam Systems, and the Nos. 4, 4A, 75 and 75A are used in conjunction with these valves for venting steam mains, risers and other quick venting service.

VACUUM VALVES

The Nos. 2, 2A Vacuum Air Valves feature the Hoffman Double Air Lock consisting of the vacuum check and vacuum diaphragm. These valves are for use on coal burning hand or stoker fired One Pipe Vacuum Systems; and for venting ends of steam mains or heating risers, where it is also desired to prevent the return of air into the system, the Nos. 16A, 76 and 76A vents are used

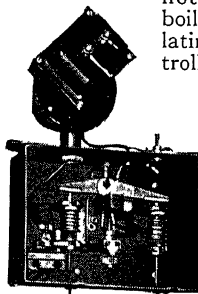


*Hoffman No. 2A
Vacuum Valve*

HOT WATER CONTROLLED HEAT EQUIPMENT

The Hoffman Temperature Controller is connected by capillary tubing to the Outdoor Temperature Bulb, and to the Water Temperature Bulb installed in the supply main. Variations in outdoor and circulating water temperatures are instantly transmitted by these two Bulbs to the Temperature Controller which electrically opens or closes the Control Valve.

*Temperature
Controller*



The Hoffman Control Valve. Admission of hot water from the boiler into the circulating system is controlled by this valve.

It is opened and closed electrically when actuated by demands for more or less heat from the Hoffman Temperature Controller.



*Control
Valve*

*Available in
sizes to
correspond
with
Hoffman
Circulator.*

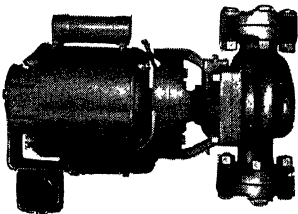
*Outdoor Temperature Bulb
located on exterior of building*



*Water Temperature
Bulb*

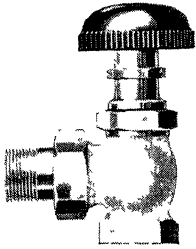


*Hoffman
Circulator*



The Hoffman Circulator is a centrifugal pump of large capacity, low power consumption and furnished in all standard sizes. It is installed in the return main and operates continuously except when outdoor temperature rises above 65 deg.

SUPPLY VALVES



*Hoffman No. 80
Supply Valve*

The Nos. 80 and 85 Packless Radiator Valves are of unique construction and proven performance.

The Reinforced Packless Feature, formed by metal cones of unequal degrees between the upper and lower members, giving a metal to metal hairline bearing and effecting a perfect seal. This short sharp bearing is further reinforced by a spring tension, and liberal gland of high quality.

Another feature is provided in the cone disc and beveled seat. This construction, as proven by test, affords protection against cracked discs.

This cone disc is reversible and its beveled seat is low in the valve body, giving perfect drainage.

Modulation in the No. 85 valve is accomplished by a cone disc nut, regulating volume of steam, according to pressure until the

valve is about two thirds open.

These valves are made with brass body union nut and tailpiece in angle and straightway patterns only in sizes from $\frac{1}{2}$ to $1\frac{1}{2}$ in.

The No. 90 is a single union gate valve embodying the same packless features as Nos. 80 and 85. This valve has a driving nut on the body for screwing it in to the radiator. The No. 90 is made in sizes $\frac{1}{2}$ to $1\frac{1}{4}$ in.

THERMOSTATIC TRAPS

Complying with the War Production Board's Limitation Order L-42 of April 23, 1942, the Hoffman line of low pressure thermostatic traps consists of the Nos. 17-D, 8-D and 9-D. These traps have a diaphragm type of thermostat, cast-iron bodies, left hand female inlets and right hand female outlets.

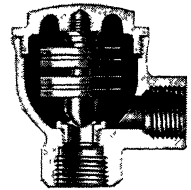
No. 17-D capacity 200 sq ft $\frac{1}{2}$ in. connections

No. 8-D capacity 400 sq ft $\frac{3}{4}$ in. connections

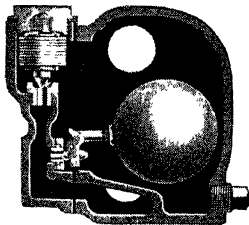
No. 9-D capacity 700 sq ft $\frac{3}{4}$ in. connections

The Nos. 8 and 9, medium pressure traps (50 pounds) have brass bodies with union nut and tailpiece. The No. 8 has a capacity of 200 sq ft and is made in $\frac{3}{8}$ in. angle pattern only, $\frac{1}{2}$ in. size in angle, R. H., L. H., and straightway pattern. The No. 9 is made in $\frac{3}{4}$ in. and 1 in. sizes, angle pattern only, capacity 600 sq ft.

The Nos. 8-H and 9-H, high pressure traps (125 pounds) have brass bodies with union nut and tailpiece. The No. 8-H is made in $\frac{3}{8}$ in. angle pattern only, and $\frac{1}{2}$ in. size in angle, R. H., L. H., and straightway pattern. The No. 9-H is made in $\frac{3}{4}$ in. and 1 in. sizes angle pattern only.



*Hoffman No. 17-D
Cast-Iron Body Trap*



No. 50 Series Trap

DRIP AND HEAVY DUTY TRAPS

Where large amounts of condensation are encountered, it is recommended to use one of the float and thermostatic traps, which are available with or without the thermostatic element. These traps are available in large capacities and are mainly used for venting and dripping risers, steam mains, unit heaters, blast coils, etc. These traps are made in four different pressure ranges 15 lb, 30 lb, 60 lb, and 125 lb.

VACUUM AND CONDENSATION PUMPS

The Hoffman-Economy line of Vacuum and Condensation Pumps offers a dependable method of economically returning the condensation from larger heating systems to the boiler. These pumps are made in single and duplex units, for varying capacities and pressures.

HOFFMAN SALES AND SERVICE

Hoffman Products are sold and stocked by leading wholesalers of heating and plumbing supplies everywhere. Hoffman representatives are available to assist in selection of suitable equipment for various services.

William S. Haines & Company

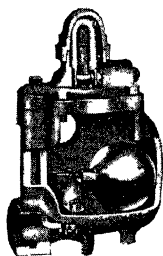
12th and Buttonwood Sts., Philadelphia, Pa.

Manufacturers of

EQUIPMENT FOR VAPOR AND VACUUM HEATING SYSTEMS

PRODUCTS—Haines Vento Radiator Traps, Medium Pressure and Blast Type Traps, Combined Float and Thermostatic Traps, Air Eliminators, High Pressure Thermostatic Traps, Boiler Return Traps, Radiator Valves.

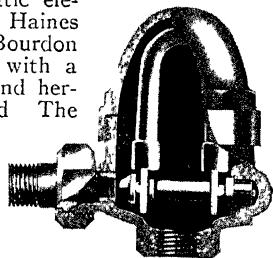
HAINES F & T TRAPS



Designed to handle large quantities of condensation. For dripping steam mains, unit heaters, hot water generators, etc. Cannot become air bound as it has a thermostatically controlled air by pass. Sizes $\frac{3}{4}$ in., 1 in., $1\frac{1}{4}$ in., $1\frac{1}{2}$ in.

HAINES RADIATOR TRAPS

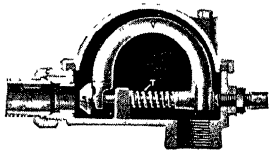
The thermostatic element in all Haines Traps is a Bourdon tube, charged with a volatile fluid and hermetically sealed. The expansion and contraction of the fluid, under varying temperatures, furnishes the operating power.



The vertical seat of this trap prevents it from becoming inoperative from scale or other foreign matter.

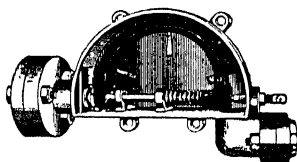
HAINES MEDIUM PRESSURE TRAPS

A ruggedly constructed bolted case trap. Ideal for hospital and kitchen equipment and all process work



operating on pressure up to 60 pounds.

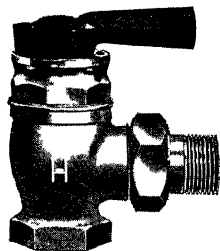
HAINES HIGH PRESSURE TRAPS



For dripping high pressure mains, laundry equipment and all process fixtures

with working pressures up to 125 pounds.

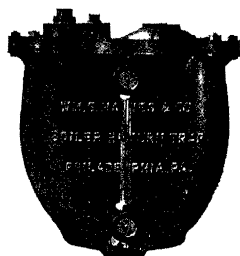
HAINES MODULATING VALVES



A packless valve assuring positive and leak proof performance. Completely opens or closes on less than a full turn of handle. Can be furnished with wheel or lever handle or lock-shield.

HAINES BOILER RETURN TRAPS

For vapor and atmospheric heating systems. Assures positive circulation by venting the air and returning the water of condensation to the boiler. Has no stuffing boxes or packed joints to leak air or water.



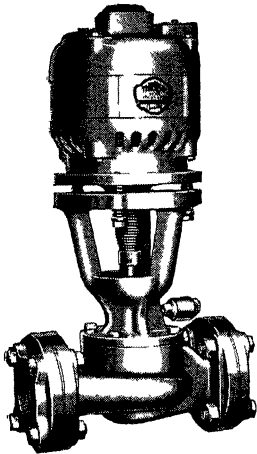
Each device is individually tested, factory adjusted and guaranteed.

H. A. Thrush & Company

Peru, Indiana

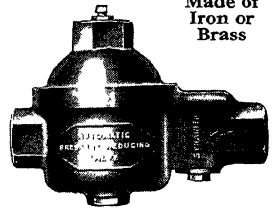
Service and Sales Offices in Principal Cities

FORCED CIRCULATING THRUSH FLOW CONTROL SYSTEM OF HOT WATER HEATING AND HEATING SPECIALTIES



THRUSH WATER CIRCULATORS

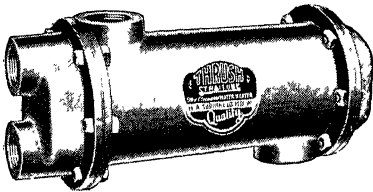
Five sizes, 1 in., 1 1/4 in., 1 1/2 in., 2 in., and 3 in., for circulating water in Heating or Domestic Water Systems. Save fuel, insure uniform heating.



Made of
Iron or
Brass

THRUSH PRESSURE REDUCING VALVES Types for High and Low Pressures

Sizes 1/4 in., 3/8 in., 1/2 in., 3/4 in., and 1 in. High pressure reducing valves are used for protecting house plumbing and heating equipment from excessive city line pressures. Low pressure reducing valves are used to reduce pressure of water entering heating system and maintain water supply in system automatically.

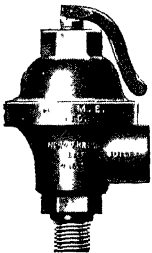


THRUSH WATER HEATERS

Highly efficient heat exchangers or converters. Sixteen sizes, for Hot Water or Steam. Pressure up to 150 lb. Straight tubes readily cleanable. Provide Domestic Hot Water at low cost. Also used industrially for heating or cooling liquids.

THRUSH HIGH PRESSURE RELIEF VALVES

Protect water supply boilers from excess pressure. Made in angle or straight types, of iron or brass, sizes 1/2 in., 3/4 in., and 1 in., for pressure relief only or combination pressure and temperature relief.



THRUSH LOW PRESSURE RELIEF VALVES

Protect heating boilers from excess pressure. Made in angle or straight types, of iron or brass, sizes 1/2 in., 3/4 in., and 1 in.

Unfailing dependability has been proved by over a quarter of a century of successful operation. Approved by Underwriters' Laboratories and comply with the A.S.M.E. Code.



Number 4
Illustrated

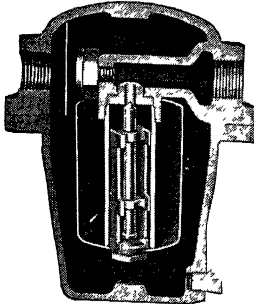
ILLINOIS ENGINEERING COMPANY

General Offices
and Factory:
Chicago



Branches and
Representatives
In Principal Cities

Illinois Steam Trap



Series 30

Valve and stem are separate from the bucket and operated only by the bucket at the extreme top and bottom of travel—result—*valve is always either full open or tight closed.* No

wire drawing or cutting of valve and seat.

Illinois Thermostatic Traps for High Pressures

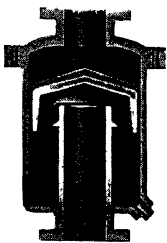


Series HG

Maximum working pressure 150 pounds. Used where neat appearance and compactness are desirable, as for trapping sterilizers or water stills in hospitals; steam jacketed kettles, coffee urns, warming tables and for process work. Also used extensively for air vents on blast type drying heaters. Multi-diaphragm of phosphor bronze Heavy duty body. Made in three sizes.

These traps are also furnished for medium pressures.

Steam and Oil Separators



Vertical Standard Separators

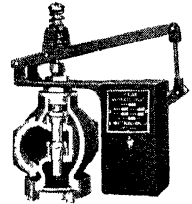
Eclipse steam separators are made in both horizontal and vertical type, and also the special receiver separators for standard or extra heavy pressures.

Eclipse oil separators are furnished in the horizontal type and have a removable baffle plate to facilitate cleaning of baffle and keeping the separator's efficiency at the highest point.

Illinois Motorized Valves (on and off)

For automatic control of steam temperatures and pressures to prevent overheating and conserve steam; to control fluid levels; and to regulate flow in hot water heating systems. May be operated by any automatic contact device or by manual switches.

Furnished in three types.



Type E

Spring Controlled Regulating Valve

Furnished in either single seated or double seated type as the service conditions require, for the control of steam, air or gas. Controlling spring is completely enclosed, protecting it from dirt and rust. Valves are furnished with the proper size diaphragm and the proper length spring to give satisfactory service under all operating conditions. Furnished also in weight loaded type, Fig. 71.

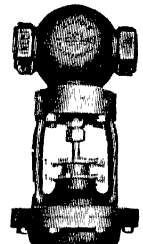


Fig. 121

Master Type Pressure Regulator

Used wherever high pressure steam must be accurately reduced in varying amount to any steady lower pressure, in service such as hospital, laundry, cooking, process, dry kilns and railway steam control. It will reduce initial pressure up to 250 pounds down to any lower pressure. Does not build up pressure on a closed or dead end line.



Fig. 142

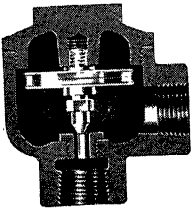
ILLINOIS ENGINEERING COMPANY

General Offices
and Factory:
Chicago



Branches and
Representatives
In Principal Cities

Illinois Thermostatic Radiator Traps



Series GW

For Vacuum and Vapor Heating Systems

Designed to conserve critical metals, the new Series GW Traps have cast-iron bodies, while the same efficient, dependable Illinois features of the internal construction

are retained. Female inlet and outlet connections with left hand thread at inlet.

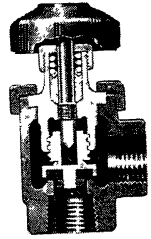
Furnished in three sizes, all angle pattern in, $\frac{1}{2}$ inch for 200 sq ft, $\frac{3}{4}$ inch for 400 sq ft and $\frac{3}{4}$ inch for 750 sq ft nominal rating.

Illinois Radiator Valves

Quick Opening, Spring Loaded, Packless Type.

Cast-iron body and bonnet conserve critical metals. The internal construction retains all of the same efficient, dependable Illinois features of the Series 40 valve.

Made in two sizes $\frac{3}{4}$ inch and 1 inch, angle pattern only. Left hand thread at inlet.



Series 40 W

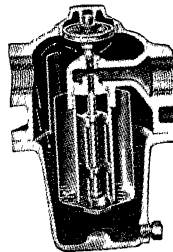
Illinois Vapor System

A two pipe low pressure steam circulating system which may be installed in any type of building, where the condensate can return to the boiler by gravity.

A sensitive damper regulator or other means of automatic control is used to control initial steam pressure above, at or below atmospheric pressure. Steam is regulated at the radiators by Illinois Modulating Supply Valves. Condensate and air are discharged from the radiator through Illinois Thermostatic Radiator Traps. In the boiler room a Vapair Vent Trap and Boiler Return Trap are installed near the boiler. The vent trap eliminates air from the system and the Return Trap insures return of condensate to the boiler.

The system and the piping arrangement are simple. No metering orifices or vacuum pumps are needed. This system will be found suitable for many installations where low first cost and low operating cost are of prime importance. May be used with unit heaters or any type of radiation.

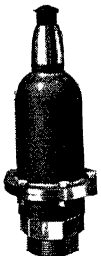
Illinois Combination F & T Traps



Series 7G

Unsurpassed for draining ventilating units, unit heaters, and for dripping mains and risers—wherever it is desirable quickly to vent air from the main as well as handle the water of condensation in quantity, whether hot or cold.

Illinois Selective Pressure Control Systems



Illinois Selective Controller

An entirely new and unique method of Steam Circulation Control . . . Heating Systems that set new standards in comfort, economy, simplicity and convenience of operation. Each system is individually engineered to meet the exact requirements. Recorded fuel savings, without sacrifice of comfort, warrant your investigation. Ask for Bulletin 16.



Boiler Return Trap



Vapair Vent Trap



Vapor Gauge



Damper Regulator

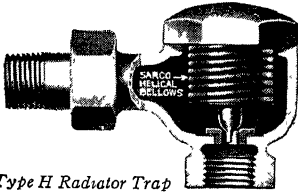
Sarco Company, Inc.

475 Fifth Ave., New York, N. Y.

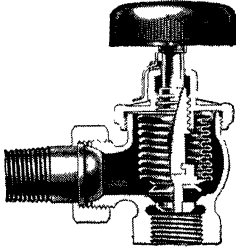
Branches in Principal Cities

SARCO CANADA LIMITED, 85 RICHMOND ST., W., TORONTO, ONT.

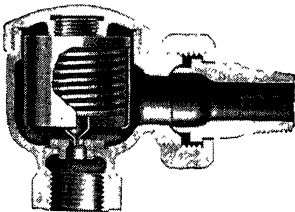
PRODUCTS—A complete line of Specialities for Vapor, Vacuum and Gravity Steam Heating Systems and Control combined with a competent Engineering Service to architects and heating engineers to assist them in providing modern heating.



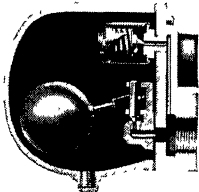
Type H Radiator Trap



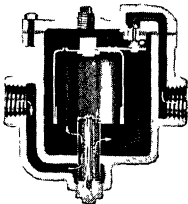
Bellows-Packless Valve



N-100 Medium Pressure Trap



Float-Thermostatic Trap



Inverted Bucket Trap

SARCO RADIATOR TRAPS

Sarco Heating Systems are "prestige Systems." The traps and valves are the system as far as maintenance and cost are concerned.

Sarco Type H Traps—Are available in angle, straightway, and corner patterns. The Sarco Thermo-static Bellows—made by special machinery, has not been duplicated or even imitated with success. It works efficiently, repeatedly and persistently. It has worked that way for a quarter of a century. Sizes $\frac{1}{2}$ in. to 1 in. Catalog HV-45.

SARCO RADIATOR VALVES

Sarco Packless Valves—Used for one and two pipe heating systems and are truly packless. Steam leaks are impossible. Furnished with round or lever handles or lock shield in angle, straightway, or corner patterns. Sizes $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. Catalog HV-45. For Hot Water Heating Systems, Catalog HV-175.

SARCO N-100 TRAP

For high pressure radiators and heating coils in stationary and marine service, and for hospital and kitchen equipment. Has full length protecting shield and stainless steel valve head and seat. Sizes $\frac{3}{8}$ in. to 1 in. Catalog HV-46.

SARCO FLOAT-THERMOSTATIC TRAPS

For dripping ends of mains and risers, and for stack or blast heaters, large unit heaters and hot water generators. Automatic thermostatic air vents built in. Available in six sizes with connections $\frac{3}{4}$ in. to 2 in. Catalog HV-450.

SARCO INVERTED BUCKET TRAPS

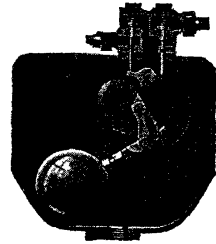
Are recommended for high pressure unit heaters and sometimes preferred for kitchen and laundry equipment. Strainers are built right into these sturdy traps. Seats and valves are stainless steel and renewable. Automatic air vents can be furnished for extra rapid removal of air. Available in sizes $\frac{1}{2}$ in. to 2 in. for pressures up to 900 lb. Catalog HV-350.

SARCO ALTERNATING RECEIVER

A complete line of boiler return traps for vapor systems.

Returns water of condensation to boiler automatically, thereby assuring positive return of water under all pressure conditions.

Made in five sizes for from 1,500 to 25,000 sq ft of radiation. Catalog HV-45.



Alternating Receiver

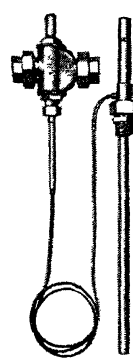


SARCO AIR ELIMINATORS

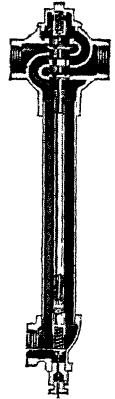
For venting air from vapor systems at one central point in the basement. Available in two sizes: No. 6 for systems up to 3,000 sq ft and No. 12-A for 15,000 sq ft. Both are equipped with float valves to stop water escaping through the vent and with check valves to prevent ingress of air when system is under vacuum. Catalog HV-45.

SARCO SELF-CONTAINED TEMPERATURE REGULATORS

Sarco Temperature Regulators are simple, self-operated valves—the only self-contained units that use the irresistible force of liquid expansion. No stuffing boxes to leak, no auxiliary “power” required; all moving parts are *inside* the equipment. Here again—a type and size for every purpose—for steam, gas, oil, water or brine for temperatures ranging from 0 to 400° F. Catalog HV-600.

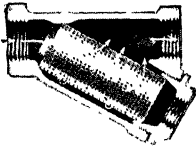


*Type TR-21
Standard for hot
water storage
tanks, fan units,
etc.*



*Water Blender
Type MB*

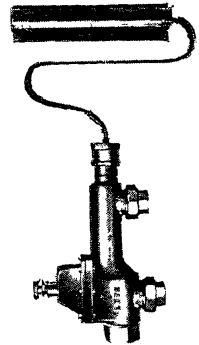
SELF-CLEANING STRAINERS



For use in pipe lines carrying brine steam, oil, gas, water, ammonia or air. Have large free screening area with minimum resistance to flow. Steam or air strainers can be cleaned by blowing through without disassembling. Made in cast iron, bronze or cast steel for pressures up to 500 lbs, with brass, iron or monel screens. Available in sizes $\frac{1}{4}$ to 8 in. Catalog No. HV-1200.

SARCO WATER BLENDERS AND TEMPERING VALVES

For mixing hot and cold water to deliver automatically water at any desired temperature. Two models are available, type MB for showers, wash basins, etc., and type DB, a tempering valve for use with submerged heating coils or tankless heaters. Catalog HV-800.

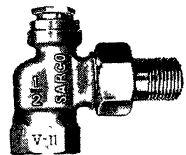


*Sarcotherm Weather
Control Valve*

SARCOTHERM HOT WATER HEATING SYSTEM

A simple, all-mechanical system for the control of radiator temperatures in direct relation to outside temperatures. Radiation is balanced by Sarcoflow fittings in the radiator outlets.

The Sarcotherm three-way valve recirculates a varying proportion of water around the boiler and back to the system as dictated by the thermostatic bulb outside the building. Catalog No. HV-175.



Balancing Fitting

WARREN WEBSTER & COMPANY

Pioneers of the Vacuum System of Steam Heating

-since 1888
Webster
Systems of
Steam Heating

Main Office and Factory:
Camden, New Jersey
Representatives in Principal Cities—
Consult Your Local Phone Directory

Webster
Nesbitt
UNIT HEATERS

NOTICE—The availability of Webster Equipment described on these pages is subject to restrictions resulting from war and priority regulations and conditions. We reserve the right to change prices, materials, and designs without notice. The low pressure steam heating specialties listed comply with WPB Limitation Order L-42, Schedule VIII.

PRODUCTS AND SERVICES

Webster Systems of Steam Heating including Vacuum and Type "R" (vapor).

Webster Central Control Systems including HYLO and MODERATOR. Modernization of Obsolete and Faulty Heating Systems.

Webster System Equipment including Light-Weight Concealed Radiation (Gravity Convection Heaters), Radiator Supply Valves, Metering Orifices, Thermostatic Traps, Drip Traps, Heavy Duty Traps, Dirt Strainers, Dirt Pockets, Boiler Return Traps, Vent Traps, Damper Regulators, Boiler Protectors, Lift Fittings, Expansion Joints, Separating Tanks, Steam and Oil Separators, Steam Vacuum Pump Governors, Air Separating and Receiving Tanks, Gages, Water Accumulators.

Webster Series "78" and Series "79" Traps for use at process pressures (10 to 150 lb per sq in.)

Webster-Nesbitt Unit Heaters and Residential Conditioners.

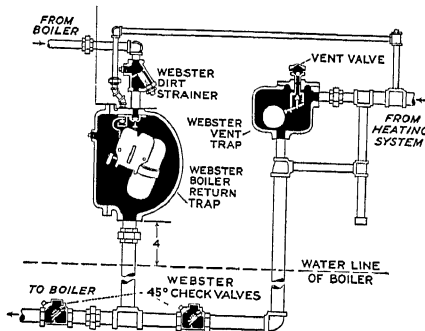


Fig 1. Conventional arrangement of piping around Webster Basement Equipment for the Webster Type "R" System

WEBSTER SYSTEMS

Webster Systems are low pressure, two-pipe systems of steam circulation *with the addition of* accurately-sized metering orifices at radiator supply connections and, when required, intermediate metering orifices at points in branch mains. Metering orifices effect even distribution of steam to all parts of the heating system and permit the successful application of a centralized control. Webster Valves are used at supply of radiators. Webster Thermostatic Traps prevent flow of steam into return mains when radiators are filled. Webster Drip Traps and Dirt Strainers are used where needed on steam mains. Webster Systems are available for vacuum, open return or "vapor" operation. The Type "R" System corresponds to the so-called Vapor type. Fig. 1 illustrates a typical arrangement of Boiler Return Trap, Vent Trap, etc., when low pressure boiler is the source of steam.

WEBSTER CENTRAL CONTROLS

These are patented systems for varying the amount of steam to all radiators according to outside temperature. They provide *continuous heat delivery* with effective *fractional filling of radiators*. The Hylo Systems may be provided for manual control, or if desired, may be semi-automatic by incorporation of inside thermostat or thermostat and schedule clock. The Moderator Systems employ an automatic Outdoor Thermostat supplemented by a manual Variator.

The latter is used for quick heating-up, night load, and unusual weather or occupancy conditions. Use of Webster Central Control Systems results in (1) increased comfort because over-heating and underheating are minimized and (2) lower fuel or steam costs.

WEBSTER SYSTEM RADIATION

Discontinued for the Duration

Concealed, non-ferrous type for use exclusively with Improved Webster Systems. Is unique in that it combines in a *single unit*, a light-weight heating element of high efficiency with an orificed radiator supply valve, a radiator trap and supply and return piping connections. Metal

enclosures for installation within the wall and exposed metal cabinets are available. Webster System Radiation and enclosures are so designed that the entire heating element can be quickly removed without damage to plaster or paint. Space requirements reduced to a minimum and installation greatly simplified.

IRON RADIATOR VALVES

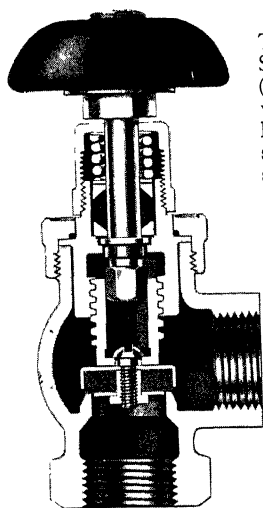


Fig 2 Webster Type "WB-P" Iron Radiator Valve

The Webster Type WB-P Supply Valve (Series 600P) with iron body has been designed to conserve critical metals. Elimination of union nut and nipple releases machine tool hours for war work. Outlet connection has female left-hand threads. Installation to radiator is by right and left-hand pipe nipple. This valve is made in $\frac{3}{4}$ and 1-in. sizes with angle body only. Furnished with wheel (mushroom) handle. Lockshield type is available to certain institutions which require it.

The Type WB-P Valve meets fully specifications calling for a "spring packless" valve. A heavy spring automatically maintains pressure on die-molded metallic ring packing. Although packing seldom requires renewing, this valve is so designed that old packing ring can be removed and new installed while pressure is on the heating system.

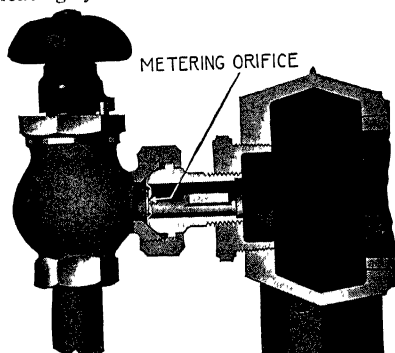


Fig 3 Metering Orifice Inserted in Union Connection of a Webster Supply Valve.

While primarily for low pressure steam heating service, the Type WB-P Valves are entirely suitable for hot water heating. Furnished with or without leak hole as desired.

Pressures—For low pressure vapor and vacuum steam heating service. Maximum pressure is 75 lb per sq in.

Metering Orifices—Accurately sized and made of metal to resist erosion and corrosion, amply thick to be free from vibration and shaped for quiet operation.

IRON RADIATOR TRAPS

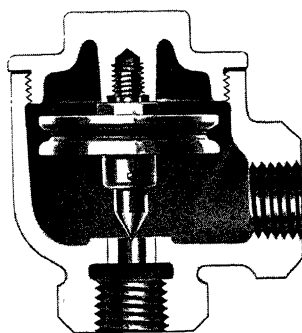


Fig 4. Webster 702 HF Iron Radiator Trap

"Old Ironsides," the war-time Webster Radiator Trap, not only effects maximum saving in critical metals but saves, in addition, needed machine tool hours through elimination of nut and nipple. Iron trap construction is not new to Webster. Experience in manufacturing iron body traps for more than 25 years has resulted in a successful design giving operating efficiency equal to earlier Webster Traps.

Construction Features—Body and cap are high quality gray cast iron assembled with steam-type gasket. Double thermostatic diaphragm is phosphor bronze, individually factory adjusted and tested. Diaphragms are compensated for pressure which means that they function efficiently at all pressures within their operating range. They do not close too quickly at certain pressures to hold up condensate while remaining open at other pressures to pass steam.

Brass valve piece is 60° cone type, factory adjusted. Flush installation of brass seat makes trap practically self-draining.

Pressures—Webster Series 7-HF Traps with iron body are designed for low pressure vapor and vacuum steam heating service. Maximum pressure is 25 lb per sq in.

Table 1. Recommended Ratings in Sq Ft E. D. R.*

The ratings below are conservative and not full-flooded capacities. Applications requiring use of higher ratings should be referred to the Company or its Representatives. When writing give full details of proposed use. Select trap by rating, not by pipe size.

Symbol	Size	Pressure Difference Across Trap in Lb per Sq In.					
		1	1½	2	5	10	15
702HF	1½"	165	200	235	370	530	640
713HF	¾"	330	400	465	730	1050	1300
723HF	¾"	580	700	810	1280	1840	2300

*Based on 240 Btu per sq ft per hour.

FLOAT-AND-THERMOSTATIC TRAPS

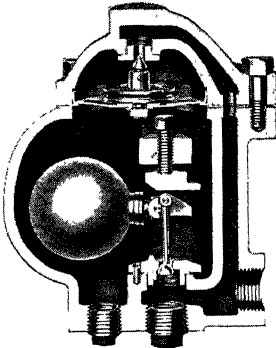


Fig. 5. Webster Size 0026-T Drip Trap will handle 1100 lb Water per Hour at 2 lb Pressure Difference

Series "26"—A heavy duty trap for drips of mains, blast radiation, unit heaters, hot water generators and similar applications. A rugged float-type trap available with and without thermostatic air vent. Made in six sizes: 400, 1100, 1600, 3000, 5000 and 11,700 lb water per hour at 2 lb pressure difference. Maximum working pressure is 15 lb per sq in.

PROCESS STEAM TRAPS

Series "78"—thermostatic trap built for process steam pressures (10 to 150 lb per sq in.). Monel Metal diaphragm. Stainless Steel valve

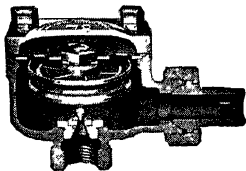


Fig. 6. Webster Size 782 Trap

piece and seat insert. Angle model only. Sizes: 3/8, 1/2, 3/4 and 1 in. Extensively used with laundry, cooking, sterilizing and other process-steam uses.

Series "79"—For use where large volumes of very hot condensate form more quickly than can be discharged by thermostatic traps alone. Float and thermostatic traps designed for normal working pressures between 15 and 150 lb per sq in. Water of condensation is passed through a float-controlled seat opening while air is discharged into the return piping by a thermostatically controlled vent. Compact and light in weight. Can be readily mounted in a pipe line without other support. Available with either 3/4 in. or 1 in. inlet and outlet.

Cast iron body, composition gasket and cover bolted together with steel cap screws. Monel Metal valve piece and stem. Stainless steel seat. Air vent unit is Monel Metal diaphragm with Stainless Steel valve piece and brass seat with Stainless Steel insert.

DIRT STRAINERS AND POCKETS

Placed in return lines of steam heating systems to prevent dirt, rust and scale from impairing tightness of traps.

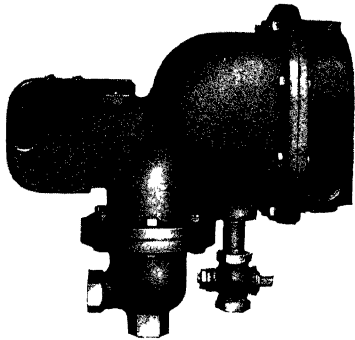


Fig. 7. Size 34C-1 Webster Boiler Protector with Low Water Electrical Cut-out Switch. Size 34 has no Cut-out Switch

BOILER PROTECTOR

Prevents breakage in low pressure heating boilers when water level becomes inadequate. Automatically supplies raw water to boiler when water level drops to 1 in. above bottom of gage glass.

For maximum boiler pressure of 15 lb per sq in. Maximum cold water main pressure should not exceed 150 lb per sq in.; minimum must not be less than 25 lb per sq in.

Made with 3/4 in. connections, with or without electrical cut-out switch.

WEBSTER-NESBITT UNIT HEATERS

Are manufactured by John J. Nesbitt, Inc., Holmesburg, Philadelphia, Pa., and are distributed solely through Warren Webster & Company, Camden, New Jersey. Designed to circulate large volumes of air at comparatively low temperatures, assuring quick heating.

Ratings of Webster-Nesbitt Unit Heaters are based on tests made in accordance with standard test code of Industrial Unit Heater Association and A.S.H.V.E.

All Products Listed are Now Available with All-Steel Coils

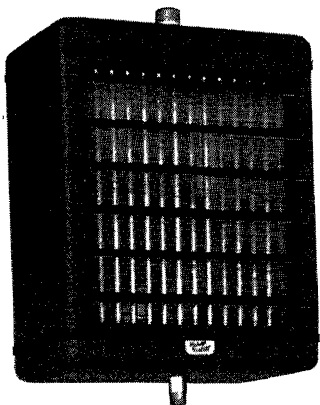


Fig. 11. Standard Propeller-Fan Type

PROPELLER FAN UNIT HEATERS

Designed to incorporate four characteristics proved by wide experience to be essential to both proper application and satisfactory performance:

1.) *Selective range of sizes.* There are eight distinct casing sizes, and these are further subdivided by variation in heating elements or fan design to produce a total of 21 basic capacities. Heating capacities at basic conditions vary from 22,300 to 338,000 Btu per hour; air deliveries from 540 to 4800 cfm.

2.) *Quiet Operation.* All fans have blades of exceptionally large areas and of a shape to impart a gradual acceleration to the air stream. Ample spacing is maintained between the fan and heating element. Motors are of sleeve bearing type and equipped with isolators.

3.) *Durable lightweight Heating Elements.* Extended fin-and-tube type, constructed of steel condensing tubes and plate-type steel fins (copper when permitted by government regulation).

4.) *Modern Casing Design.* Single, two-speed, or multi-speed motors. Compact suspended type. Catalog W-N 115.

GIANT UNIT HEATERS

Sturdy blower-fan units for the economical heating of large areas.

Standard (Non-Thermostat) Type. Used principally where heating is by recirculation only, and where constant heat output is desired during period of operation.

Thermostat Type. Employs dampers in front of casing and over face of heating element to provide mixing of unheated and heated air, producing heat output in accordance with requirements and continuous circulation of air volume.

Valve Controlled Type. Unit is of standard casing arrangement but equipped with Nesbitt Heating Surface with Steam-distributing Tubes which allows for automatic control of heat output.

Floor mounted, wall mounted, ceiling suspended, from 125,000 Btu, 3330 cfm, to 1,008,000 Btu, 16,000 cfm. Available with Non-metallic casings. Write for details. Catalog W-N 116.

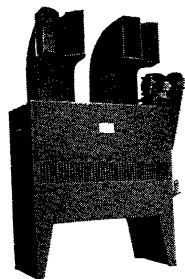


Fig. 12
Blower-Fan Type

LITTLE GIANT UNIT HEATERS

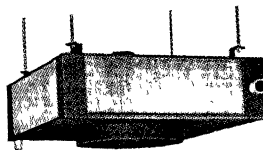


Fig. 13
"Little Giant" Down Blow Type

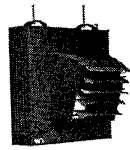


Fig. 14.
Horizontal Blow

New, light compact drawn-through high velocity units in down blow and horizontal blow models. 39,000 Btu, 710 cfm to 530,000 Btu, 11,000 cfm at basic rating of 2 lb steam and 60 deg entering air.

Down Blow Type. In general indicated when the presence of cranes and other machinery requires that the unit and piping be located well above floor level.

Horizontal Blow Type. Application follows principles of heat distribution regularly employed in suspended blower fan type heater. Units are located closer to working zone than Down Blow type.

Available with Non-metallic casings. Write for details. Catalog W-N 114.

SERIES F UNIT HEATERS With Non-Metallic Casings

Floor type, centrifugal fan units in two casing sizes. For lobbies, corridors and offices. Complete information on request.

McDONNELL & MILLER

Safety Devices for Steam and Hot Water Boilers and Liquid Level Controls

General Offices: Wrigley Building, Chicago, Ill.

"Doing one thing well"

PRODUCTS:

Boiler Water Feeders; Feeder-Cut-off Combinations; Low Water Fuel Cut-offs; Pump Controls, Low Water Alarms; Humidifier Water Level Controls; Safety Relief Valves for hot water heating boilers and storage tanks; Liquid Level Controls for a wide range of services.

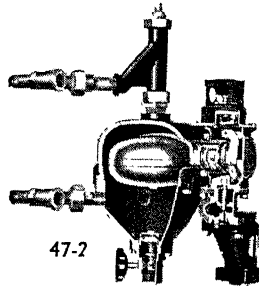
Boiler Water Feeders—McDonnell boiler feeders protect steam boilers from low water by automatically supplying water to the boiler when and as needed. See illustrations and service data opposite.

Feeder Cut-off Combinations—For automatically fired boilers the No. 2 Low Water Cut-off Switch is added to form a feeder-cut-off combination, like the No. 47-2, No. 51-2, etc. In such a combination the feeder takes care of the normal water requirements. In case of an emergency, such as excessive priming and foaming or failure of the pump, the low water cut-off switch stops the burner until emergency is passed. Electrical ratings of No. 2 Cut-off Switch: A.C.— $\frac{3}{4}$ hp, 110-220 V.; D.C.—10 amp, 125 V.

Low Water Fuel Cut-offs—If the feeder-cut-off combination is not desired, the No. 67 alone can be installed to dependably stop the burner when low water threatens. Has two switches—one operates alarm or controls No. 101 Electric Feeder, other acts as low water cut-off. Rating (each switch): A.C.— $\frac{3}{4}$ hp, 115-230 V; D.C.— $\frac{1}{4}$ hp, 115 V.

For high pressure jobs the No. 150 will serve not only as a low water fuel cut-off but also as a pump control and low water alarm—for pressures as high as 150 lbs. Electrical ratings, Cut-off and Pump Control: A.C.—1 hp, 110-220 V; D.C.— $\frac{1}{2}$ hp, 115-230 V. Alarm: A.C. or D.C.—1 amp, 110 V. Specify 150-M for manual reset low water cut-off.

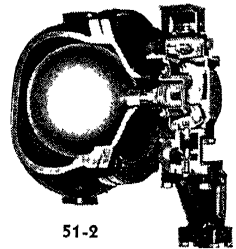
Advanced Features—A notable advance in No. 47 and 67 is the deep sediment chamber, with large capacity, straight-through (A.S.M.E. Standard) blow-off valve. Other features of feeders and cut-offs include: Quick-Hook-Up; Cool feed valve; finer stainless steel valves; large area built-in strainers; double switch construction of the No. 67; electric boiler water feeders; self-cleaning built-ins.



47-2

No. 51-2 Feeder-Cut-off Combination. For automatically fired boilers above 5000 sq ft—maximum steam pressure 35 lbs. No 51 (without switch) for hand fired boilers. For pressures from 35 to 75 lbs use the No 53 (Hand Firing) No 53-2 (Automatic Firing)

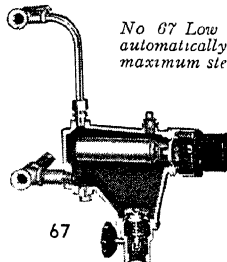
"Built-in" Low Water Fuel Cut-offs—chosen as standard equipment on modern jacketed boilers. Self cleaning to insure dependable operation. Should be specified with the boiler.



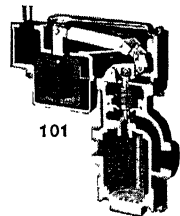
51-2



No. 67 Low Water Fuel Cut-off. For automatically fired boilers of any size, maximum steam pressure 25 lbs

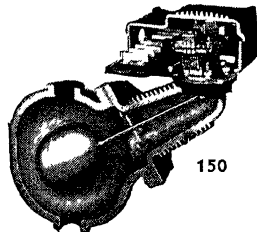


67



101

No. 101 Electric Water Feeder for use with No. 67 or Built-in cut-offs—converts into Feeder-Cut-off Combinations



150

No. 150 Combination Pump Control, Low Water Fuel Cut-off and Alarm. for steam pressures up to 150 lbs. Has two switches: one controls pump—other stops burner and completes alarm circuit when water level falls to danger zone.

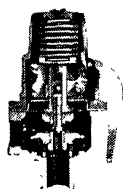
McDonnell Snap Action Safety Relief Valves

McDonnell Safety Relief Valves are the first to be rated in Btu capacity—in ability to dissipate heat at their set relief pressure. Their “snap action” design was inspired by exhaustive research which proved that the only proper solution to the problem of preventing explosions and losses of hot water boilers, domestic hot water heaters, and hot water tanks was to be found in a valve that would have sufficient discharge capacity at relief pressure to prevent further pressure rise when the boiler or domestic water heater is operated at

maximum gross Btu output.

The series includes Nos. 29 and 129 for hot water heating boilers and the Nos. 229, 329 and 429 for domestic hot water heaters and tanks. The snap action mechanism (Pat. No. 2,248,807) provides, for the first time, a precision-built means of opening the valve wide at set pressure. Revolutionary features are hardened stainless steel cone instead of composition disc; long lived bellows diaphragm; remarkable ease of testing; complete protection of working parts; many other refinements.

No. 29 and No. 129 Safety Relief Valves for Hot Water Heating Boilers



No 29-129

—are rated in Btu capacity so that they can be matched to the gross Btu output of the boilers on which they are used:

No. 29 for heating boilers with gross heat output up to 150,000 per hour.

No. 129 for heating boilers with gross heat output up to 350,000 per hour.

Set relief pressure of both No. 29 and 129 is 29 lbs. When used in accordance with their ratings they will prevent pressures over 29 lbs under *all conditions*—even such an emergency as a bottled up system with

all temperature-limiting devices inoperative and heat input at maximum. This is “safety the McDonnell Way.”

No. 229-329-429 Safety Relief Valves for Domestic Hot Water Heaters and Tanks



No 229
329-429

Engineering fundamentals, confirmed by practical tests prove that there is just one simple rule to observe in protecting domestic hot water heaters and tanks: Keep the pressure below the maximum allowed by the manufacturer of the tank or heater and there will be no failures or explosions.

To accomplish this, a relief valve must have capacity to dissipate the maximum heat to which the tank can be subjected. This means that it must be Btu-rated, just as for a hot water boiler, so that it can

be matched to the service condition. Nos. 229, 329 and 429 are so rated:

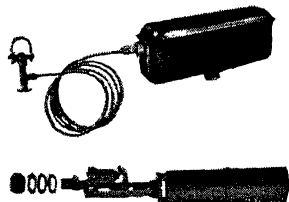
No. 229 is for water supply pressure up to 50 lbs; handles approximate Btu output of 316,720. Inlet tapping 1 in.; outlet tapping $\frac{3}{4}$ in.

No. 329 is for supply pressure up to 75 lbs; handles Btu output of 380,896. Inlet tapping 1 in.; outlet tapping $\frac{3}{4}$ in.

No. 429 is for supply pressures up to 100 lbs; handles Btu output of 432,590. Inlet tapping 1 in.; outlet tapping $\frac{3}{4}$ in.

Never forget the pressure control—not temperature control—is the fundamental safety measure. You can have pressure and breakage without excess temperature, but you can't have an explosion at any temperature, unless you have excess *pressure*. No. 229, 329 and 429 are the first valves to be built and rated in such a way that they will prevent excess pressure under *all conditions*—assuming, of course, that their Btu rating is properly observed.

McDonnell No. 217 Humidifier Water Control

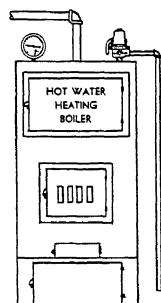


• No. 217 Complete with float chamber, tubing and saddle valve.

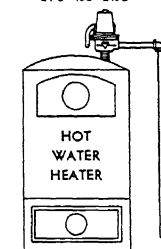
• No. 117. Same as 217, omitting tubing and saddle valve

• No 17. Float and valve only

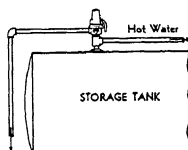
—automatically maintains proper water levels in evaporation pans of warm air furnaces. New snap action eliminates tendency of former controls to become stopped up by foreign matter or to stick and become inoperative. This valve has only two positions—tight closed and *wide open*. When water falls $\frac{1}{4}$ in. in pan it *snaps* wide open feeding a full stream that flushes orifice. Closes leak-tight against any water pressure up to 150 lbs.



Installation
No 29-129



On Direct
Fired Heaters



On Storage Tank

AMERICAN & Standard RADIATOR & Sanitary

New York CORPORATION Pittsburgh

OUR TWO-FOLD WAR PRODUCTION PROGRAM

From the outset we have supplied large quantities of peacetime products for cantonments, hospitals, housing, airports, battleships, submarines and other Army and Navy requirements. We will continue to supply this demand on authorized orders.

Vital parts for Guns, Tanks, Planes and Ships are also being produced in considerable variety with adaptable peacetime equipment, and conversion of facilities to meet other specialized war needs is being prosecuted vigorously.

We pledge our all to Victory.

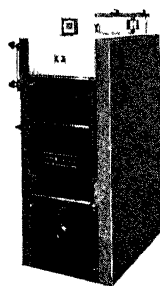


SEVERN BOILER FOR COAL (stoker or hand-fired), or OIL

An exceptionally efficient Boiler with many new features for convenience and economy. Ratings: Steam—350 to 780 sq ft, Water—560 to 1250 sq ft, installed radiation.

ARCOLINER FOR COAL (stoker or hand-fired) or OIL

An attractive boiler of advanced design for heating smaller homes inexpensively and well. Ratings: Steam—180 to 460 sq ft, Water—290 to 740 sq ft, installed radiation.

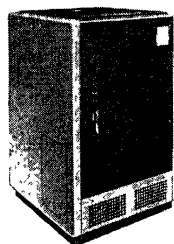
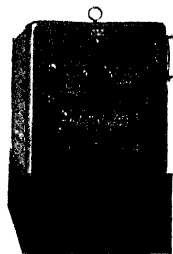


OAKMONT OIL BOILER

A highly efficient moderate priced Boiler for small homes. Also supplied as complete boiler-burner unit with Arcoflame Burner. Ratings: Steam—390 to 810 sq ft, Water—625 to 1295 sq ft, installed radiation.

IDEAL ARCOFIRE STOKER-BOILER

Extra efficient, extra economical—especially designed for automatic stoker operation only. Ratings: Steam—900 to 1,775 sq ft, Water—1,440 to 2,840 sq ft, installed radiation.

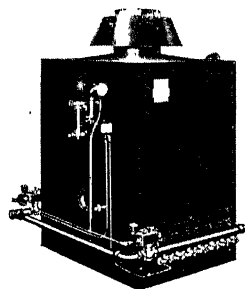


"EMPIRE" GAS BOILER

Designed by experts to burn gas efficiently, economically. All controls concealed. Ratings: Steam—163 to 1097 sq ft, Water—135 to 1755 sq ft, installed radiation.

STANDARD GAS BOILER

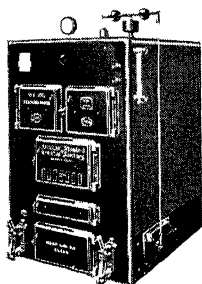
Basically the same as the "Empire" Gas Boiler shown at left, but without jacket. Ratings: Steam—400 to 11,905 sq ft, Water—135 to 19,050 sq ft, installed radiation.



AMERICAN & Standard RADIATOR & Sanitary

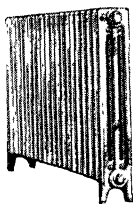
New York CORPORATION Pittsburgh

Our ability to furnish products shown
herein is subject to War Time regulations.



IDEAL REDFLASH BOILERS (All Fuels)

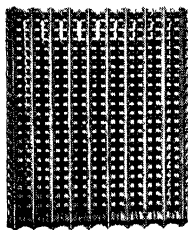
Economical heat for
any size or kind of
building. Attractive
red jacket, fully in-
sulated. Ratings:
Steam—770 to 11,085
sq ft, Water—1230 to
17,736 sq ft, installed
radiation.



Arco Radiator

ARCO RADIATOR

The modern, slim type
radiator that occupies less
space and gives more heat.
It comes in four narrow
widths and in four heights
—19, 22, 25 and 32 inches.

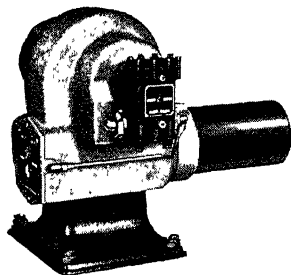


Vento

VENTO CAST-IRON BLAST SURFACE

For blower heating,
ventilating, cooling.
Vento possesses an
unusually large area
of effective surface
for maximum effi-
ciency. Cast-iron
construction assures
dependability and
permanence.

ARCOFLAME OIL BURNERS

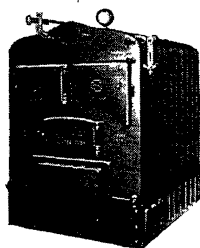


The Model
"C" Arcoflame
has a capacity
of up to 3 gal-
lons per hour.
The Model "L"
(not shown)
from 3 to 7 gal-
lons per hour.
Both embody
unusual and
highly efficient
features.

AMERICAN HEATING EQUIPMENT COSTS NO MORE THAN OTHERS

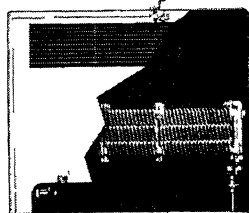
IDEAL WATER TUBE BOILERS (Oil or Stoker Fired)

For medium to large
size buildings. Noted
for efficient perfor-
mance and economy.
Ratings: Steam—650
to 4600 sq ft, Water
—1040 to 7360 sq ft,
installed radiation.



ARCO CONVECTOR

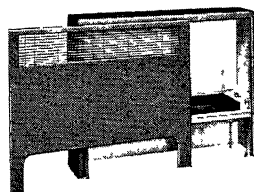
For convection
heating at its
best. Available
in four widths
and in virtually
any desired
length.



Arco Convector

ARCO MULTIFIN CONVECTOR

Non-ferrous.
Highly effi-
cient. For all
systems except
one-pipe steam.
Available in
five widths.



Arco Multifin



No. 861 Arco
Detroit Hur-
vent Valve
(for main)



No. 300 Arco
Detroit Multi-
port Valve (for
radiators)



No. 999 Arco
Packless Steam
Radiator
Valve

THE BABCOCK & WILCOX COMPANY

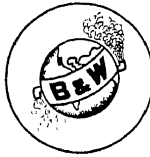
85 Liberty Street

Manufacturers of

New York, N. Y.

Water-Tube Boilers

Oil Burners



Chain-Grate Stokers

Seamless Steel Tubing and Pipe

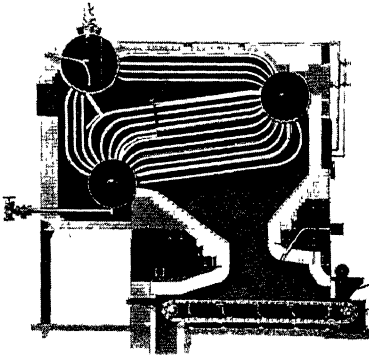
Branch Offices and Representatives in all Principal Cities

Type H Stirling Boiler

The Babcock & Wilcox Type H Stirling Boiler is a highly efficient unit built for moderate pressures at moderate prices. . . and is designed to occupy minimum floor space and head room for the heating surface required.

This boiler is built in four classes and 36 sizes ranging from 691 to 6225 sq ft of heating surface, and can be designed for operation with any fuel and every method of firing.

The moderate price is due only to the simplicity of design, efficient production methods and superior shop equipment.



Type H Stirling Boiler with Babcock & Wilcox Chain-Grate Stoker

Advantages of the Babcock & Wilcox Type H Stirling Boiler:

Unusual steaming capacity for the floor space and head-room required.

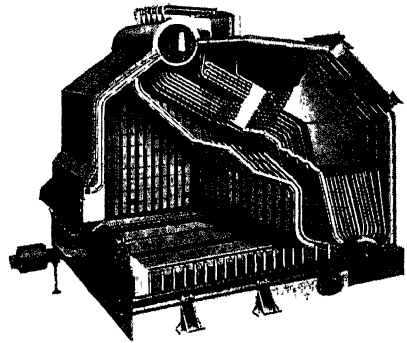
The choice of three locations for gas exit reduces cost of flues and breeching.

Distribution baffles make effective all of the heating surface.

Tube renewal is facilitated by correct tube spacing, and a tube removal door.

The boiler is supported by a structural-steel framework entirely independent of the brickwork.

A complete table of sizes and dimensions will be sent upon request. Simply ask for Bulletin G-8-C.



B&W Integral-Furnace Boiler, Type FF

Many of the advantageous features incorporated in large B&W central-station boilers are now available for the first time in the B&W Integral-Furnace Boiler, Type FF, which is offered in sizes ranging from 1353 to 6506 sq ft heating surface.

Distinguishing features include:

A completely water-cooled furnace. The construction provides water cooling for front and rear (or bridge) walls, as well as side walls and roof.

A furnace arrangement in which the primary combustion zone is followed by an open pass, thus making use of a principle of combustion that was first developed and used successfully in the B&W Open-Pass Boiler for central stations. This design insures mixing of the gases while at high temperatures, thereby aiding efficient and smokeless combustion.

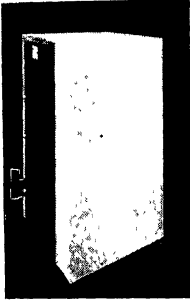
Cyclone Steam Separators, which provide dry steam at high boiler-water concentrations independently of normal variations in water level, and increase circulation by eliminating steam from the water.

These, with related features, result in a boiler that is outstanding for economy of fuel and maintenance and for ease of operation. Write for Bulletin G-34

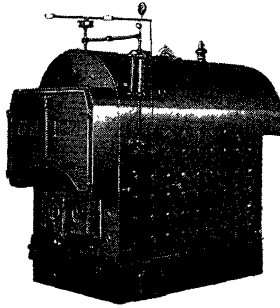
Burnham Boiler Corporation

Irvington-on-Hudson, N. Y.—Zanesville, Ohio

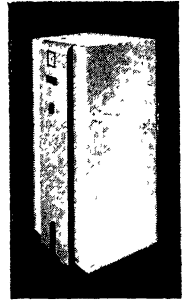
There's a Burnham for Every Purpose—Catalogs Sent on Request



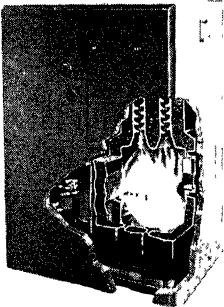
Yellow Jacket Boiler
—All Fuel Convertible.
305 to 935 sq ft for
steam and 490 to 1495
for water.



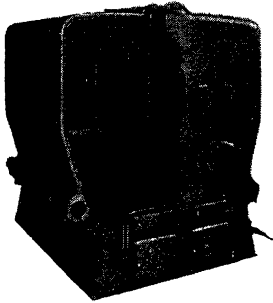
Welded Steel Boiler — Resi-
dence type with jackets. Capa-
cities from 400 to 1750 sq ft
steam and 640 to 2800 for water.
Commercial type. Capacities
from 1800 to 42,500.



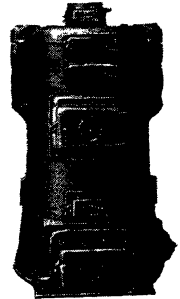
Junior Yello-Jacket
—For Oil Only. 360
sq ft steam and 580
sq ft for water.



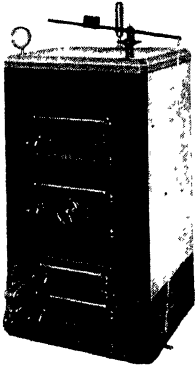
**DeLuxe Gas or Oil
Boiler**—250 to 960 sq
ft steam and 415 to
1540 for water.



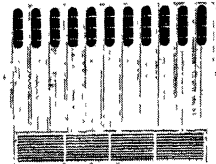
50 Inch Twin Section—
4500 to 14,600 sq ft steam
and 7200 to 23,360 for
water.



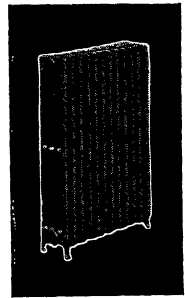
**Round Sectional, All
Fuel**—275 to 830 sq ft
steam and 440 to 1330
for water.



**No. 1, 2, 3 and 36 in.
Series**—All Fuel. 230
to 4920 sq ft steam and
370 to 7880 for water.



**Cabinet Type Radi-
ant Radiator** — Two
heights. 20 and 23
inches.



**Burnham Slenderi-
zed Radiator**—Made
in 3 to 7 tubes in
heights of 14 to 32
inches.

Crane Co.

**BOILERS, RADIATORS, VALVES, FITTINGS, PIPE, STEAM SPECIALTIES,
PLUMBING AND HEATING MATERIALS**

General Offices: 836 South Michigan Avenue, Chicago, Illinois
Nation-Wide Service Through Branches, Wholesalers, Plumbing and Heating Contractors

A complete line of heating equipment—boilers and furnaces for coal, coke, oil, or gas burning—for steam, hot water, or

warm air systems. Full descriptions and specifications are given in your Crane Catalog—or supplied on request.

BOILERS FOR SMALL HOMES



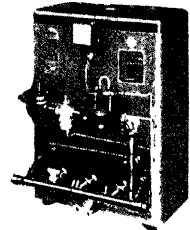
SERIES FOURTEEN

Wet base, low return inlet. Patented controlled water travel. Large ceiling heating surface. Internal heater and jacket optional. For steam or hot water. Capacities: manual firing, up to 90,000 Btu., oil or stoker up to 119,000 Btu. (IBR).



CONSERVOIL UNIT

Low-priced boiler-burner unit in 4 sizes up to 131,000 Btu. (IBR) Controlled water travel, large ceiling surface, and flue inserts assure fuel economy. Includes burner, draft regulator and 3 controls. For steam or hot water.



**No. 2WG
BASMOR GAS BOILER**

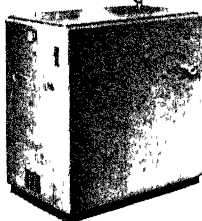
New hot water boiler for smallest homes. Sections are cast-iron with water-jacketed combustion chamber. Fully automatic. Shipped completely assembled; housing, controls in position. Up to 110,800 Btu. net capacity.

BOILERS FOR AVERAGE-SIZE HOMES



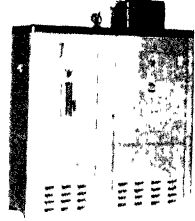
No. 10 ALL-FUEL BOILER

Can be installed for manual firing—easily converted for stoker, oil or gas firing. High base and removable grate lugs give ample space for stoker or oil burner. Provision for internal heater. For steam or hot water. Net capacity up to 207,000 Btu. (IBR).



**No. 16 SUSTAINED HEAT
BOILER-BURNER UNIT**

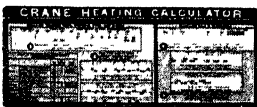
Application of Crane sustained heat principle extracts more heat from fuel. Down-draft flue construction prevents escape of combustion gases before heat has been absorbed. Net capacity up to 216,000 Btu. (IBR). Steam or water.



No. 25 BASMOR GAS BOILER

Unusual efficiency obtained with staggered fin construction and improved Bunsen-type burners. Safe, can't back-fire. Simple controls. Many sizes; for manufactured and natural gas. Net capacity to 177,400 Btu. Steam or hot water.

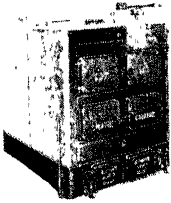
CRANE HEATING CALCULATOR FREE



With this accurate calculator, employing the A.S.H.&V.E. method of determining heat losses, you can quickly select the right boiler and radiator requirements for any job. Easy to use—slide rule type. Free on request. Please write on your letterhead to address at top of this page.

BOILERS FOR LARGER BUILDINGS

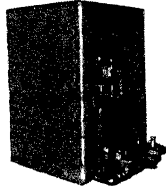
No. 4 SECTIONAL BOILER



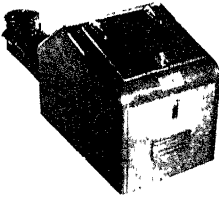
For manual, oil, and stoker firing. Up to 1,756,800 Btu. net capacity—steam or hot water.

SERIES 60 BASMOR GAS BOILER

Has built-in steam header with Hartford return loop. Up to 2,857,200 Btu. net capacity—steam or hot water.



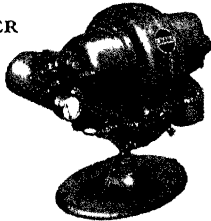
AUTOMATIC HEAT-CONVERSION UNITS AUTOCOAL STOKER



For even, controlled room temperature with minimum attention. Hopper models: 20 to 350 lb. per hour capacity. 35 and 50 lb. bin-feed models.

CONSERVOIL BURNER

Will burn lower grades of fuel oil. Only one moving part. Quiet; cannot foul. Models up to 25 gal. per hour capacity.



CONTROLS



Low Voltage Re-
lay-Transformer



Room
Thermostat



Draft
Tender

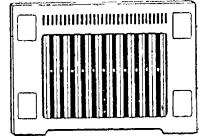
A full line of precision-built Crane controls including room thermostats, night set-back clocks, oil and stoker controls, limit switches for steam, hot water, and furnace systems.

The Crane line includes valves, fittings, and pipe for all boiler and radiator systems; a selection of furnaces for coal, oil, and gas; also split-system equipment and well-water cooling for year 'round air conditioning.

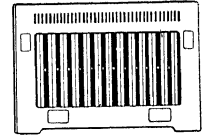
HEATING ELEMENTS—ALL TYPES

COMPAC SLIM-TUBE RADIATORS

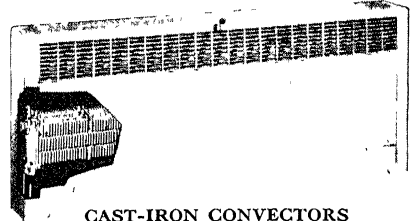
Cast-iron; space-saving. Modern slender design. For free-standing or recessed installation—with or without attractive front panel. Maximum delivery of radiant, infra-red ray heat. Further space-saving with bottom connections.



End Connection



Bottom Connection

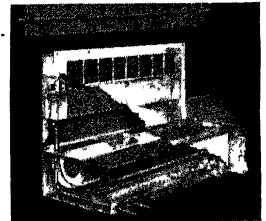


CAST-IRON CONVECTORS

Enclosures of heavy steel, smartly styled. Models for fully or partially recessed, free-standing, wall-hung, and plaster-front installations. Convectors of sturdy cast-iron with large integral fins designed to stimulate air flow. For all systems.

DUCTLESS WINTER AIR-CONDITION- ING UNIT

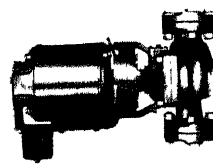
Recessed in wall and floor; no sheet metal work. Provides heat, humidification, filtering and circulation.



FOR LARGE SPACE HEATING REQUIREMENTS, SPECIFY CRANE SPEED HEATERS.

Made in a Complete Line.

HEATING SPECIALTIES



Circulating Pump

Crane supplies a complete range of hot water specialties including circulators, flow



Steam
Venting
Valve

controls, monoflo fittings, pressure tank systems, indirect heaters. Also, air valves, traps, condensation and vacuum pumps, low water cut-offs, and other steam specialties.



Fitzgibbons Boiler Company, Inc.

Established 1886

General Offices: Architects Bldg., 101 Park Avenue
New York, N. Y.

Works: OSWEGO, N.Y.

Branches and Representatives in Principal Cities

PRODUCTS—STEEL HEATING and POWER BOILERS for all fuels and all heating systems. Capacities to meet requirements of any building. Built and rated according to *S. H. B. I. Code*. —**AIR CONDITIONERS** for "Split-Systems" and for Direct-Fired installations in residences of all sizes.

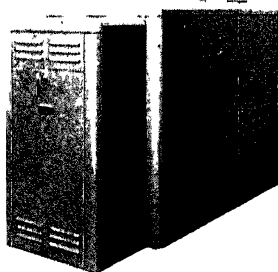
WARM AIR FURNACE 80 FWA

For hand firing with coal. Automatically controlled blower provides forced circulation of warmed air. Designed in accordance with the specifications of Procurement Division of the U. S. Treasury Department and of FWA, USHA, PBA and FSA for Defense housing. Fitzgibbons "Weldseal" construction positively insures against leakage of flue gases.

Bonnet capacity, 80,000 Btu based on Standard Code of National Warm and Air Conditioning Asso.

DIRECT-FIRED AIR CONDITIONERS

The **DIRECTAIRE**—The conditioner that has broken the shackles of traditional "hot air furnace" design, providing far greater Efficiency, Ruggedness, Quietness, Fuel Economy, Cleanability. Streamlined jacket in two types. Nine sizes—65,000 to 600,000 Btu at the bonnet.



FITZGIBBONS 400 SERIES STEEL BOILERS

The choice of architects and builders wherever low cost heating in small homes is needed. Beautifully adapted to defense housing using radiator heat with oil, gas or stoker firing, or with coal hand firing. Built-in coil provides domestic hot water. All the advantages of Fitzgibbons steel boiler construction in an attractively jacketed unit, priced for the field it serves. Five sizes—260 sq ft (steam or vapor, hand fired) to 1440 sq ft (Hot water system, mechanically fired.)

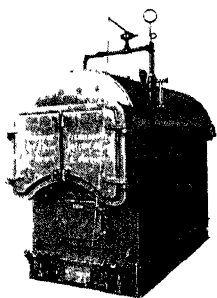
FITZGIBBONS "EIGHTY" SERIES STEEL HEATING BOILERS

The **OIL-EIGHTY AUTOMATIC***—An outstanding residential steel boiler that teams up with any good rotary or gun type burner to form a highly efficient unit. Provides room for burner inside the jacket. Year-'round tankless domestic hot water optional. Ratings, Steam—12 sizes—425 to 2680 sq ft

The **GAS-EIGHTY**—For gas. Jacketed. Ratings, Steam—12 sizes—425 to 2680 sq ft.

FITZGIBBONS R-Z-U- JUNIOR—For oil, stoker, coal hand firing. Auxiliary grate (optional) for refuse disposal and stand-by service. Tanksaver or Tankheater (optional) provides year-'round domestic hot water supply with or without storage tank. Ratings, Steam, hand fired type, 900 to 3200 sq ft. Oil or stoker fired, 1100 to 3900 sq ft.

*Reg. U. S. Pat. Office.

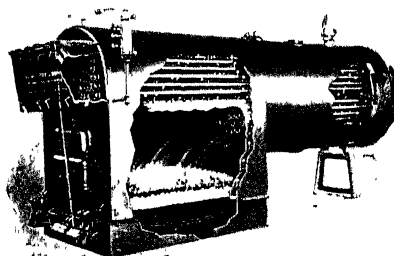


"D" Type

FITZGIBBONS "D" TYPE

Steel Firebox Boilers

The "D" Type arranged for rear smoke outlet.
Built for 15 lb w.s.p.—*A.S.M.E.* Code.
Up-Draft Type.....1800 to 35,000 sq ft steam
Oil, Gas, Stoker.....2190 to 42,500 sq ft steam
Smokeless Type.....1800 to 35,000 sq ft steam

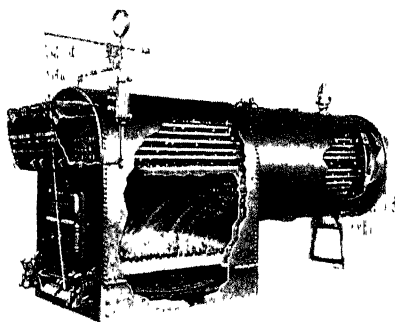


500 Series

FITZGIBBONS 500 SERIES

Portable Welded Firebox Boilers— Return Tubular

Built for 15 lb s.s.p.—*A.S.M.E.* Code.
Ratings, steam....3500 to 35,000 sq ft hand fired.
4250 to 42,500 sq ft mech. fired.
Oil, Gas, Stoker, and hand-fired types.

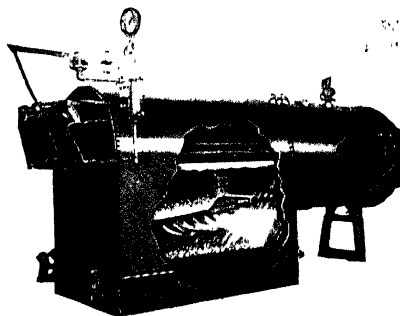


700 and "P" Series

FITZGIBBONS 700 AND "P" SERIES

Portable Riveted Firebox Boilers

700 Series for 15 lb w.s.p.—*A.S.M.E.* Code.
Ratings, steam—3500 to 35,000 sq ft hand fired.
4250 to 42,500 sq ft mech. fired.
"P" Series for 100 and 125 lb w.s.p.—*A.S.M.E.*
Code.
Ratings, horsepower—25 to 250 hand fired.
30 to 261 mech. fired.
Oil, Gas, Stoker, and hand-fired types.



600 and 800 Series

FITZGIBBONS 600 AND 800 SERIES

Smokeless Down-Draft Riveted Firebox Boilers

600 Series for 15 lb w.s.p.—*A.S.M.E.* Code.
Ratings; steam—3500 to 35,000 sq ft hand fired.
4250 to 42,500 sq ft mech. fired.
800 Series for 100 and 125 lb w.s.p.—*A.S.M.E.*
Code.
Oil, Gas, Stoker and hand-fired types.
Ratings, horsepower—25 to 250 hand fired.
30 to 261 mech. fired.

When this catalog went to press, all products and accessories described herein were available for sale. Government priorities or other circumstances beyond our control may now affect delivery. Consult the nearest Fitzgibbons Sales Engineer for up-to-date information. Descriptive Bulletins on any or all of above boilers will be mailed on request.

Farrar & Trefts

Incorporated

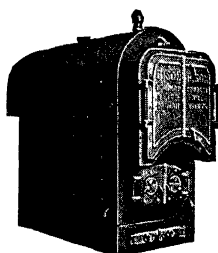
20 Milburn Street, Buffalo, N. Y.

ATLANTA, GA.
AUBURN, N. Y.
BATAVIA, N. Y.
BUENOS AIRES, S. A.
BUTTE, MONT.
CAMBRIDGE, MASS.
CHARLOTTE, N. C.
CHATTANOOGA, TENN.

CHICAGO, ILL.
CLEVELAND, OHIO
DALLAS, TEXAS
DETROIT, MICH.
GRAND RAPIDS, MICH.
HUTCHINSON, KAN.
INDIANAPOLIS, IND.
JAMESTOWN, N. Y.

KINGSTON, PA.
LOS ANGELES, CALIF.
LOUISVILLE, KY.
MINNEAPOLIS, MINN.
NASHVILLE, TENN.
NEW YORK, N. Y.
NUTLEY, N. J.
PITTSBURGH, PA.

RICHMOND, VA.
ROCHESTER, N. Y.
ST. LOUIS, MO.
SAN ANTONIO, TEXAS
SAN FRANCISCO, CALIF.
SEATTLE, WASH.
TOLEDO, OHIO
WASHINGTON, D. C.



The Bison Compact

The F&T Bison Compact Welded Heating Boiler is more than just another boiler. It has been designed carefully so as to have a large furnace volume, the proper volume of water, just the right amount of steam liberating surface, the correct volume for steam storage and a balanced circulation. The result is a remarkably steady water line—A Balanced Boiler.

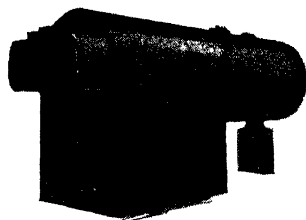
This boiler requires a minimum amount of floor space and is easy and inexpensive to install. It is reasonable as to first cost and economical in operation. Construction is in accordance with the A.S.M.E. Code for 15 lb working pressure and boilers are designed for hand firing with anthracite or bituminous coal or for mechanical firing with oil, gas or stoker. There are various sizes available from 1800 to 35,000 sq ft of steam

radiation, all ratings as required by the *Steel Heating Boiler Institute*.

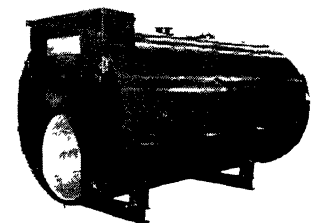
The Bisonette Compact Boiler has the same characteristics as the larger Bison Compact Boiler. It has been designed for installation in large residences and small business establishments where the advantages inherent in a Steel boiler are desired.

Firebox Return Tubular Heating Boilers are **Quality Boilers**. They are constructed to measure up to the high standards set by Heating Engineers and will give unfailing service under all conditions. Being economical to install and operate, they are highly favored by Architects and Engineers for heating Schools, Hospitals, etc.

There are two types of Firebox Boilers, the Up-Draft Type and the Down-Draft Type. Both types are made of welded or riveted construction for heating purposes at 15 lb working pressure and riveted, or, Class 1 fusion welded x-rayed and stress-relieved for power purposes at 100, 125 and 150 lb working pressure in accordance with the A.S.M.E. Code. Sizes from 1800 to 35,000 sq ft of steam radiation, as rated by the *Steel Heating Boiler Institute*, are designed for hand firing with coal or for mechanical firing with oil, gas or stoker.



Firebox Return Tubular Boiler



The Bison Low Pressure Scotch Wet-Back Top Boilers are *carefully proportioned* and *balanced*. They are designed for hand, oil, gas or stoker firing, for ratings from 15 to 250 hp. These boilers operate efficiently and carry sustained overloads. The *Front Smokebox Door Open Sideways* giving easy access to the tubes.

The *Wet-Back Top* increases the heating surface and steam disengaging area, thus adding to the capacity of these boilers. F & T boilers are designed so that the round furnace is always longer than the tube length which increases the furnace volume. This gives a large combustion volume in proportion to horsepower rating which makes the boilers very *economical to operate* and exceedingly "*Quick Steamers*."

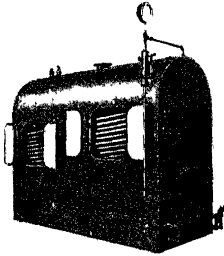
The International Boiler Works Company

East Stroudsburg, Pa.

"Fuel Saver" Water Tube Steel Heating Boilers

SALES OFFICES IN PRINCIPAL CITIES

International "FUEL SAVER" Water Tube Steel Heating Boilers offer the same quick steaming and economy that have long been accepted as most efficient in marine and industrial service. "FUEL SAVER" Water Tube Boilers are available for large and small heating requirements in a wide range of types and capacities.



TYPE C "FUEL-SAVER" WATER TUBE STEEL HEATING BOILERS

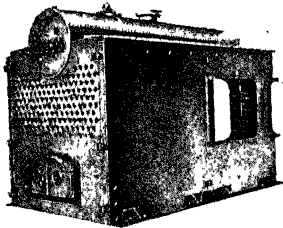
For Office and Apartment Buildings, Schools, Hotels, Theaters, Institutions and Industrial Plants

Built in a complete range of standardized sizes and provide highly efficient performance for heating large buildings.

Up-to-date water tube design permits absorbing the intense heat released by modern methods of firing and they will operate efficiently under loads considerably in excess of ratings.

18 sizes { from 2680 to 42,500 sq ft mechanically fired rating
 { from 2200 to 35,000 sq ft hand fired rating.

TYPE KD "FUEL-SAVER" WATER TUBE STEEL HEATING BOILERS



For Replacement Installations in Large Buildings Eliminates Costly Cutting and Patching

Especially designed for renovation and replacement work. Shipped knocked down in standardized parts that can be taken through existing doors or openings to basement and boiler room.

INTERNATIONAL erects or assumes full responsibility for erection work of knocked down boilers.

15 sizes { 5850 to 56,470 sq ft mechanically fired rating
 { 4810 to 46,510 sq ft hand fired rating.

TYPE FR STEAM GENERATOR UNIT Scotch Type with Forced Recirculation

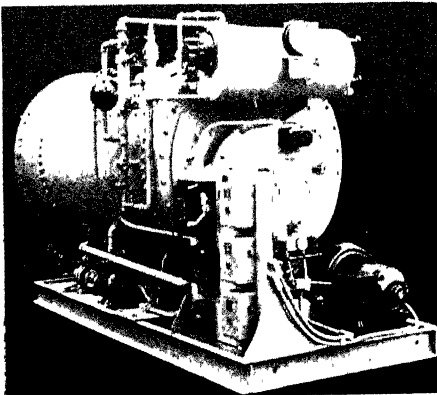
For Military, Marine, and Civil-Power, Processing, or Heating

The TYPE FR Steam Generator is a compact and completely coordinated self-contained unit, with an exceedingly low space, weight, and horsepower ratio.

Standard construction and equipment has been stressed in the design and manufacture of Type FR Steam Generators.

Operators quickly recognize that the familiar features and extreme simplicity of these units guarantee easy maintenance and trouble-free operation.

TYPE FR Steam Generators are mounted on rigid steel chassis, with all auxiliary equipment necessary for self-contained and automatic operation when connected with electrical, fuel oil, and feed water supply lines.



TYPE FR Steam Generators are furnished in all standard working pressures, from 15 to 200 pounds per square inch, and from 20 to 300 boiler horsepower.

ADVANTAGES

1. **Portability**—Type FR Steam Generators are complete package units.
2. **Minimum Installation Time**—Every unit is adjusted and tested before shipment, for efficient performance at rated capacity.
3. **No Stack**—Primary and secondary air for efficient and smokeless combustion are furnished by forced draft fan. A small exhaust vent is all that is required.
4. **FUEL SAVER**—Overall efficiency 80 per cent +.

Licensed under LaMont Patents

Kewanee Boiler Corporation

Kewanee, Illinois

BRANCHES IN 64 PRINCIPAL CITIES

Steel Heating and Power Boilers, Water Heating Garbage Burners, Tabasco Heaters and Tanks.

KEWANEE STEEL HEATING BOILERS

Kewanee offers a dependable line of Steel Boilers built for heating every size building, with high efficiency, burning any kind of fuel. There are 380 standard sizes and 33 types of Kewanee Boilers most of which are kept in stock, ready for immediate delivery.

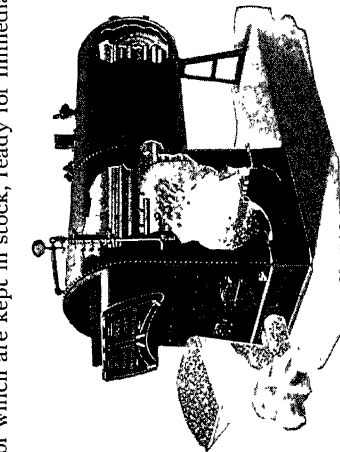
Seventy-five years of intensive study and effort are back of Kewanee Boiler designs. They are all constructed in our extensively equipped factory at Kewanee, Illinois, in conformity with these Codes: *American Society of Mechanical Engineers* for construction, and for rating with the *Steel Heating Boiler Institute* Simplified Practice.

The Kewanee series include:

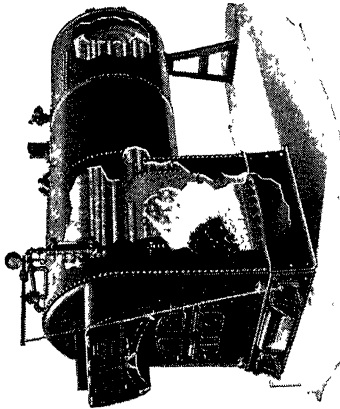
HEAVY DUTY RIVETED FIREBOX TYPES: 1,240 ft to 42,500 ft. Brickset and portable settings, Updraft and Downdraft Smokeless Furnace, Single-pass tubes for rear smoke outlet; Two-pass tubes for front smoke outlet.

WELDED BOILERS: 2,200 ft to 42,500 ft. Direct Draft or Smokeless Arch with Corrugated Crown Sheet. Rear Smoke outlet and Weld + Rivet for front Smoke outlet.

RESIDENCE STEEL BOILERS: 790 ft to 2,924 ft. Square Type "R" with and without Jackets and Hot Water Heating Coils for Storage Tank or Instantaneous flow.



Firebox Boiler for Stoker
"400" and "500" Series



Firebox Boiler Portable Up-draft Type
"400" and "500" Series

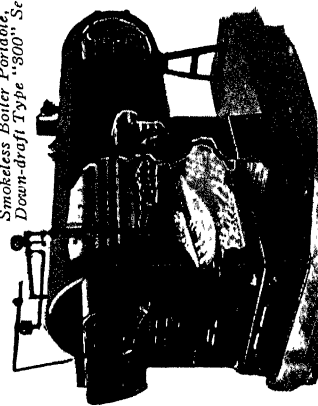
SPECIFICATIONS—PORTABLE UP-DRAFT BOILER

Boiler No.	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590
					480	481	482	483	484	485	486	487	488	489	490
Rated Steam Capacity:															
Coal,	3500	4000	4500	5000	6000	7000	8500	10000	12500	15000	17500	20000	25000	30000	35000
Oil, Gas or Stoker	4250	4860	5470	6080	7290	8500	10330	12150	15180	18220	21250	24290	30360	36430	42500
Width and Length	42x8-7	42x9-6 1/2	48x8-10	48x9-6 1/2	54x11-5	54x13-1 1/2	60x13-4 1/2	60x15-5 1/2	66x18-0 1/2	72x17-7 1/2	78x17-7 1/2	84x20-7	84x23-4	84x23-4	84x23-4
Overall Height	80	80	86	86	94	94	101	101	107	107	113	115	115	125	125
Height of Water Line	70	70	73	73	79 1/2	79 1/2	84 1/2	84 1/2	89 1/2	89 1/2	94	96 1/2	96 1/2	103	103
Approximate Weight:	6100	6700	7300	7900	10200	11400	13300	14800	17300	19700	22000	24300	28400	32300	36100
	5500	6100	6600	7100	9300	10400	12200	13600	15800	18100	20300	22300	26400	30200	33800

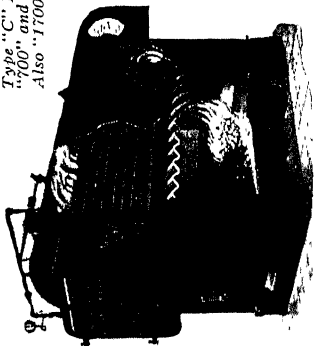
* Rated Capacity for Water Boiler is 60 per cent greater than Capacity for Steam Boiler.

Table for two series of Boilers lists maximum dimensions only.

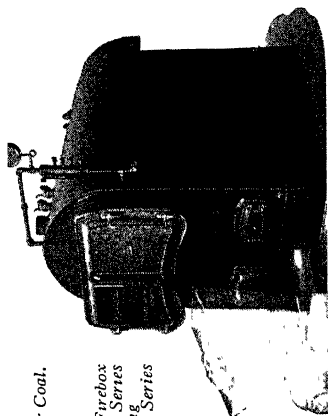
Smokeless Boiler Portable,
Down-draft Type "800" Series



Type "C" Boiler
"700" and "9700" Series for Coal.
Also "1700" Series for Oil



At Right
Type "C" Hi-Firebox
Boiler "7L70" Series
for Stoker Firing.
Also "27L70" Series
Hand Fired



SPECIFICATIONS—SMOKELESS DOWN-DRAFT BOILER

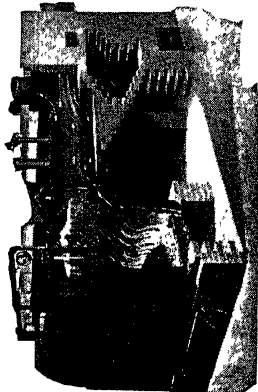
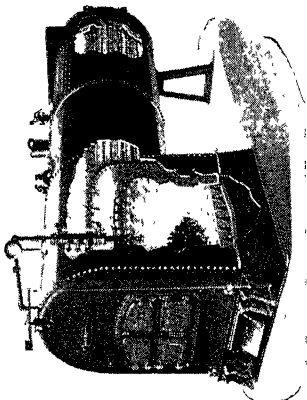
Boiler No.	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390
Rated Steam Capacity:															
Coal	3500	4000	4500	5000	6000	7000	8500	10000	12500	15000	17500	20000	25000	30000	35000
Oil, Gas or Stoker	4250	4860	5470	6080	7290	8500	10330	12150	15180	18220	21250	24290	30360	36430	42500
Width and Length	42x8-3	42x9-3	48x8-7½	48x9-5	54x11-2½	54x12-11	60x12-6½	60x14-9	66x14-11	66x17-4	72x16-5	78x17-0½	78x20-7½	84x19-11	84x22-8
Overall Height	80	80	86	86	94	94	101	101	107	107	113	115	115	125	125
Height of Water Line	70	70	73	73	78	78	85	85	88½	88½	94½	95	95	107½	107½
Approximate Weight:															
Coal	6800	7500	8100	8800	10000	11100	13600	15300	18000	22900	25100	29500	33600	37500	37500
Oil	6200	6900	7400	8000	9100	10100	12500	14100	16500	18900	21200	23200	27500	31500	35200

SPECIFICATIONS—TYPE "C" WELDED BOILER

Boiler No.	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790
Rated Steam Capacity:																	
Coal	2200	3000	3500	4000	4500	5000	6000	7000	8500	10000	12500	15000	17500	20000	25000	30000	35000
Oil, Gas or Stoker	2680	3160	3650	4250	4860	5470	6080	7290	8500	10330	12150	15180	18220	21250	24290	30360	36430
Width and Length	36x5-10	36x6-10	36x7-9	42x7-10½	42x8-6½	42x9-2	48x9-4½	48x10-7	54x9-11	54x12-11	60x12-6½	60x14-9	66x14-11	66x17-4	72x16-5	78x17-0½	84x19-11
Overall Height	77½	77½	77½	77½	83½	83½	86½	86½	89	89	95	95	101	101	103	115	135
Height of Water Line	69	69	69	69	72	72	75	75	78	78	85	85	94	94	101	114	114
Approximate Weight:																	
Coal	3900	4400	5000	5500	6000	6500	7500	8400	9700	11000	12900	14900	16600	18400	22000	25200	28400
Oil	3400	3800	4300	4800	5300	5800	6700	7600	8100	9400	10600	12500	14400	16100	17900	21200	24400
2700 Series, Coal	3300	3700	4100	4600	5000	5400	6100	6900	8000	9100	10700	12300	13800	15400	18100	20900	23400

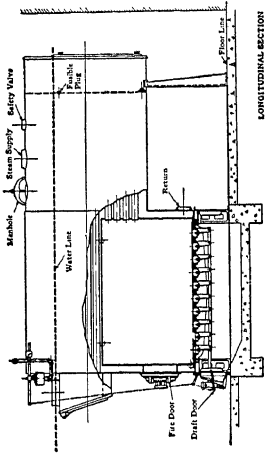
SPECIFICATIONS—TYPE "C" HI-FIREBOX WELDED BOILER

Boiler No.	7L73	7L74	7L75	7L76	7L77	7L78	7L79	7L80	7L81	7L82	7L83	7L84	7L85	7L86	7L87	7L88	7L89	7L90
Rated steam capacity:																		
Stoker	2680	3160	3650	4250	4860	5470	6080	7290	8500	10330	12150	15180	18220	21250	24290	30360	36430	42500
Width x Length, In. x Ft. In.	36x5-10	36x6-10	36x7-9	42x7-10½	42x8-6½	42x9-2	48x9-4½	48x10-7	54x9-11	54x12-11	60x12-6½	60x14-9	66x14-11	66x17-4	72x16-5	72x18-11	78x14-9½	84x15-11½
Overall Height	82½	82½	82½	82½	88½	88½	94½	94½	94½	108	108	119½	123	131	134	140	156	161
Height of Water Line	74	74	74	77	77	77	81	81	81	94	94	105	106	111	117	121	136	140
Approximate Weight	3100	3500	3900	4400	4900	5400	5800	6700	7600	8800	10000	11800	13600	15300	17000	20100	23200	26100



Brickset Boiler Up-draft Type

Type "K" Up-draft Boiler



Weld + Rivet Firebox Boiler "5000" Series Up-draft, Also "6000" Series Smokeless Down-draft

SPECIFICATIONS—BRICK-SET AND TYPE "K" PORTABLE UP-DRAFT BOILERS																			
Boiler No.	3K	4K	5K	6K	8K	9K	10K	11K	12K	13K	14K	15K	16K	17K	18K	19K	20K	19	20
Rated Steam Capacity:																			
Coal	Sq Ft	1240	1380	1800	2200	3000	3500	4000	4500	5000	6000	7000	8500	10000	12500	15000	17500	20000	20000
Oil, Gas or Stoker	Sq Ft	1770	2020	2190	2680	3650	4250	4860	5470	6080	7290	8500	10330	12150	15180	18220	21250	24290	24290
Width and Length	In. x Ft	30x9-10	36x8-10	36x11-10	42x11-4	42x12-10	48x11-10	48x13-4	48x14-10	54x15-3	54x17-9	60x17-0	60x19-6	66x19-6	72x16-0	72x16-0	72x16-0	78x19-4	78x19-4
Overall Height	In.	59	65	65	55	55	58 1/2	71	77	77	83	93	93	93	105	107	107	107	107
Height of Water Line	In.	52	55	55	55	58 1/2	61	61	61	66	66	66	75	75	85	85 1/2	85 1/2	85 1/2	85 1/2
Approximate Weight:	Coal	3500	3900	4200	4700	5700	6400	7000	7600	8200	9500	10700	12600	14500	17600	20700	23800	26900	29000
	Oil	3130	3550	3800	4200	5100	5800	6400	6900	7400	8600	9700	11500	13300	16100	19100	22100	25200	28300
SPECIFICATIONS—WELD + RIVET FIREBOX BOILER "5000" SERIES																			
Boiler No.	5076	5077	5078	5079	5080	5081	5082	5083	5084	5085	5086	5087	5088	5089	5090				
Rated Steam Cap:																			
Coal	Sq Ft	3500	4000	4500	5000	6000	7000	8500	10000	12500	15000	17500	20000	25000	30000	35000	40000	45000	50000
Oil, gas or stoker	Sq Ft	4250	4860	5470	6080	7290	8500	10330	12150	15180	18220	21250	24290	30360	36430	42500	48500	54500	60500
Diam. x Length	In. x Ft	42x7-3	42x8-0	42x8-11	42-9-10	48-9-9	48x11-1 1/4	54x12-9	60x13-2 1/2	66x14-0 1/2	72x15-0 1/2	78x16-0 1/2	84x17-0 1/2	90x18-0 1/2	96x19-0 1/2	102x20-0 1/2	108x21-0 1/2	114x22-0 1/2	120x23-0 1/2
Overall Height	In.	81	81	81	81	86 1/2	86 1/2	92 1/2	92 1/2	92 1/2	100 1/2	105	105	112	117	122	127	132	137
Height of Water Line	In.	70	70	70	70	73 1/2	73 1/2	78	78	84	84	86	86	94 1/2	96	102	107	112	117
Approx. Weight:	Coal	5100	5600	6100	6600	7500	8400	9600	10800	12600	14400	16100	17900	21200	24400	27500	30600	33700	36800
	Oil	4500	5000	5400	5800	6600	7400	8500	9600	11000	12800	14400	16000	19200	22300	25400	28500	31600	34700
SPECIFICATIONS—WELD + RIVET SMOKELESS BOILER—"6000" SERIES																			
Boiler No.	6077	6078	6079	6080	6081	6082	6083	6084	6085	6086	6087	6088	6089	6090					
Rated Steam Capacity:																			
Coal	Sq Ft	4000	4500	5000	6000	7000	8500	10000	12500	15000	17500	20000	25000	30000	35000	40000	45000	50000	55000
Oil, Gas or Stoker	Sq Ft	4860	5470	6080	7290	8500	10330	12150	15180	18220	21250	24290	30360	36430	42500	48500	54500	60500	66500
Diameter x Length	In x Ft	42x8-2	42x8-8	42x9-6	48x9-7	48x11-0	54x10-8 1/2	54x12-4 1/2	60x12-9 1/2	66x14-0 1/2	72x15-0 1/2	78x16-0 1/2	84x17-0 1/2	90x18-0 1/2	96x19-0 1/2	102x20-0 1/2	108x21-0 1/2	114x22-0 1/2	120x23-0 1/2
Overall Height	In	81	81	81	86 1/2	86 1/2	92 1/2	92 1/2	92 1/2	100 1/2	105	105	112	117	122	127	132	137	142
Height of Water Line	In	70	70	70	73 1/2	73 1/2	78	78	84	84	86	86	94 1/2	96	102	107	112	117	122
Approximate Weight:	Coal	5800	6300	6800	7700	8600	9900	11200	13100	14900	16600	18300	21500	24500	27500	30500	33500	36500	39500
	Oil	5100	5600	6100	7000	7800	8900	10100	11900	13500	15100	16700	19800	22700	25700	28700	31700	34700	37700

Kewanee Type "R" Residence Boilers

Kewanee Type "R" Boilers are especially designed and constructed to meet all heating and hot water requirements for homes and small buildings. Every kind of solid fuel, coke, all grades of hard or soft coals and their briquette or treated forms are burned with excellent results. Also, any liquid fuel, oil, and natural or

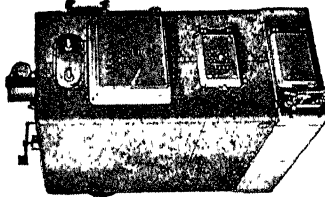
commercial gas can be used with high efficiency.

Standard snug fitting jackets, or Regal style for completely enclosing burners are available for 83R.

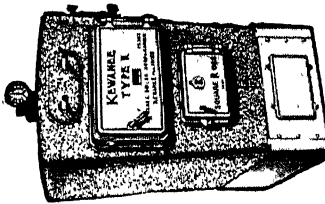
Hot Water Copper Coil. Capacities up to 720 may be ordered for Square and 83R Boilers.



Square Type "R" Residence Boiler



Square Type "R" Jacketed Boiler



83R Oil or Gas Jacketed Boiler

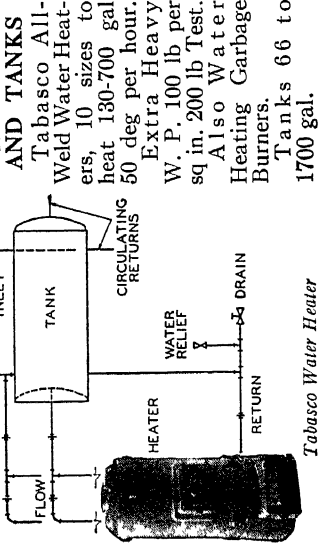
Kewanee Storage Water Heaters
Kewanee Storage Heaters—use exhaust or live steam. 15 Standard Coil Elements in 29 standard size storage tanks. Capacities 95 to 2240 gals.

Kewanee Scotch Marine Boilers
Kewanee Scottie Junior for High Pressure Steam in small industrial usage. 5 sizes, 9.9 to 30 hp at 100 lbs steam pressure.

Kewanee Welded Scotch Marine, Low Pressure Steam. 18 sizes, 2680 to 42500 sq ft, mechanically fired.

Kewanee Hi-Test Boiler
Kewanee Hi-Test Fusion Welded Series for High Pressure Steam in power or industrial process. 6 stock sizes, 50 to 150 hp, 125 and 150 lbs steam working pressure. All A.S.M.E. Code.

Kewanee Water Heaters and Tanks



SPECIFICATIONS—RESIDENCE SQUARE TYPE "R" BOILER													
*Boiler No.	742	743	745	746	747	748							
Rated Steam Capacity: Coal	790	1000	1350	1600	1780	1960							
Oil, Gas or Stoker	Sq Ft	Sq Ft	Sq Ft	Sq Ft	Sq Ft	Sq Ft							
Width and Length	840	1120	1470	1900	2160	2380							
Overall Height	In.	In.	In.	In.	In.	In.							
Shell Top	32 5/8	32 5/8	32 5/8	32 5/8	32 5/8	32 5/8							
Height of Water Line	48	48	58 1/2	70 1/4	70 1/4	70 1/4							
Approximate Weight: Coal	2150	2360	2800	3050	3300	3550							
Oil	1900	2060	2500	2730	2920	3125							
Standard Jacket, Crated	205	225	175	190	200	225							
Boiler No., Square "R" Oil or Gas	83R1	83R2	83R3	83R4	83R6	83R7	83R8	83R9					
Rated Steam Capacity	901	1105	1326	1513	2091	2363	2652	2924					
Approximate Weight with Jacket	Sq Ft	Sq Ft	Sq Ft	Sq Ft	Sq Ft	Sq Ft	Sq Ft	Sq Ft					
	1600	1800	2000	2200	2800	2900	3100	3300					

*Boiler Series 1742-1748 for Oil, Gas or Stoker; 2742-2748 for Anthracite, Kewanee Indirect Hot Water Heating Coils for Type C and Square "R" Boilers; 55 sizes, 90 to 1520 Gal.

Spencer Heater

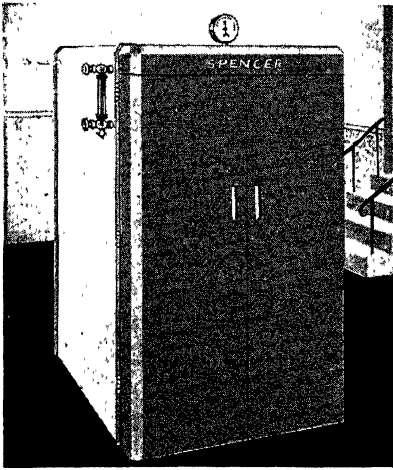
Division—The Aviation Corporation

Williamsport, Pa.

Sales Representatives in Principal Cities

Spencer Automatic Magazine Feed Heaters are furnished in cast iron sectional types—and steel tubular types for larger buildings—for steam, vapor and hot water heating. There is a size and capacity for every type of building, to provide economical and convenient heat—safe, dependable, sure.

COMFORTABLE HEAT AT LOW COST



Spencer Jacketed Heater L-1 Series

Why Spencer Heaters perform so satisfactorily can best be explained by an inspection of their design and construction. The Spencer principle, illustrated in the cross-sectional view, is simple:

Once a day fuel (No. 1 Buckwheat Anthracite or small size by-product coke) is put into the magazine. It fills the sloping grate to the level of the magazine mouth. The fire bed always stays at the proper level, for as fast as fuel burns to ash, it shrinks and settles on the sloping grate; and more fuel rolls down automatically over the top of the fire bed. Fuel feed is by gravity alone, in just the right amount to keep the fire always burning at its most efficient combustion point.

This explains why a Spencer Automatic Magazine Feed Heater always gives the same uniform, satisfying heat, and burns less fuel. These exclusive Spencer advantages are available in all types of the magazine feed heaters and boilers.

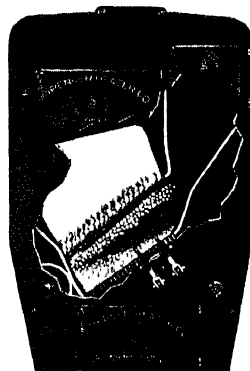
Coal — Coke — Gas — Oil — Spencer J and L series heaters and M series boilers are primarily designed to burn low cost No. 1 Buckwheat Anthracite or small size coke.

If at any time a property owner desires to burn more expensive fuels—oil or gas—his Spencer Heater can be readily converted and will show a high efficiency.

Thermostats—Thermostats and electric damper motors are furnished as optional equipment.

Jacketed Covering—Illustrated in the attractive metallic jacket of the deluxe enclosing type for Spencer Cast Iron Heaters, either with or without the enclosing jacket doors.

Spencer Heavy Duty Tank Heaters—With the automatic magazine feed construction, they provide ample domestic hot water at lowest cost, and with a minimum of tank heater attention.



Cutaway sectional view Spencer Cast Iron Heater

SPENCER ALL YEAR SYSTEM

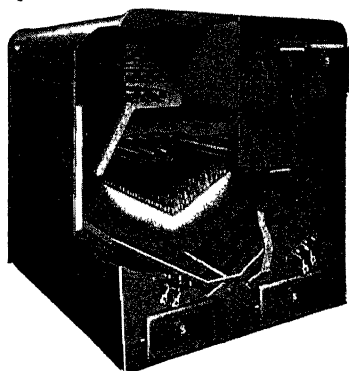
In addition to the excellent heating facilities afforded by Spencer Magazine Feed Heaters, Year Round Domestic Hot Water Service can also be provided and

assures at all times an ample supply of domestic hot water at lowest cost. Complete data for installation and operation upon request.

SPENCER STEEL TUBULAR MAGAZINE FEED BOILERS

For large buildings we recommend Spencer Steel Tubular Magazine Feed Boilers, burning low cost No. 1 Buckwheat Anthracite or coke.

In the cross-section diagram, part of the fire bed is cut away to show the sloping grates and the two magazines filled with fresh coal, ready to feed down automatically by gravity to the fire. These boilers are built in two vertical sections for ease in handling and installation—a great advantage on replacement jobs, eliminating the necessity of costly tearing out of walls or partitions. Combination water and fire tube construction; built to A.S.M.E. standards.



Steel Tubular Magazine Feed Boiler

SPENCER STEEL TUBULAR BOILERS For Oil, Stoker, Gas or Hand-Firing

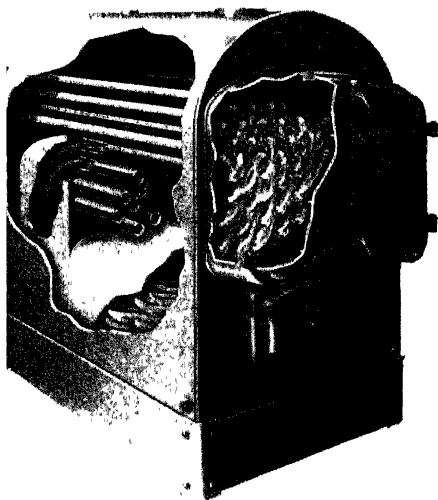
For more than 55 years, Spencer has been building, in the opinion of experts, one of the most efficient, economical and dependable automatic coal burning boilers on the market. With this background of experience, Spencer Engineers developed the Spencer Steel Tubular Boiler for oil, gas, stoker and hand-firing—the “K” and

“C” series for residential use, and the Type “A” for larger buildings. They are better boilers both for the property owner and for the architect or engineer who specifies them.

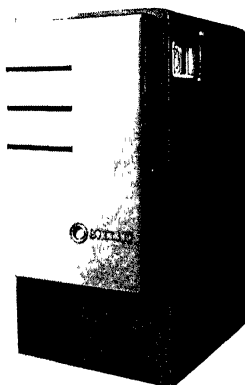
The high sustained efficiency of these boilers means adequate heat for a lower fuel cost. Design is of the three pass type. Combustion chamber is amply large. Built of best quality open hearth steel boiler plate, and steel tubes. Can be furnished with domestic hot water heating coils, storage tank or instantaneous type.

A complete range of sizes from 400 sq ft

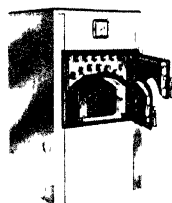
SHBI net steam rating up. They meet or exceed in every particular the requirements of the A.S.M.E. and S. H. B. I. Codes.



Type “A” Steel Boiler



“C” Series Steel Boiler



“K” Series

Every Spencer Boiler is guaranteed to carry more than its full rated load giving the installer a definite factor of safety.

These boilers have all the advantages of the Spencer exclusive design and are readily adapted to mechanical oil or stoker firing—or hand-fired coal or coke.

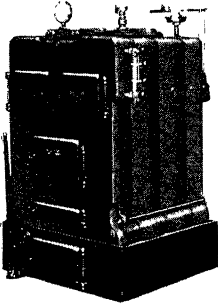
UNITED STATES RADIATOR CORPORATION

General Offices: Detroit, Michigan

Branches and Sales Offices in Principal Cities

Detroit, Michigan

CAPITOL RED TOP BOILERS



"B" Series
Unjacketed
Boiler

"A" Series—All Fuels

Boiler No.	Capacity Square Feet		I-B-R Sq Ft Direct Cast Iron Radiation	
	Steam	Water	Steam	Water
A-7	770	1235	340	545
A-8	980	1565	440	705
A-9	1190	1900	540	865
A-10	1395	2235	640	1025
A-11	1605	2565	740	1185

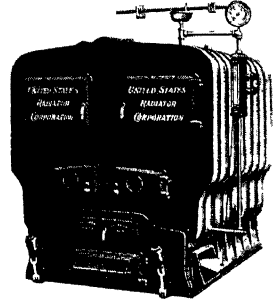
"B" Series—All Fuels

B-8	1875	3000	920	1470
B-9	2210	3535	1110	1770
B-10	2520	4035	1275	2040
B-11	2790	4460	1440	2300
B-12	3035	4855	1580	2530
B-13	3280	5245	1730	2770
B-14	3525	5640	1880	3000

"C" Series—All Fuels

Boiler No.	Capacity Square Feet		Direct Cast Iron Radiator Loads Sq Ft	
	Steam	Water	Steam	Water
C-12	4700	7760	2250	3600
C-14	5600	9240	2715	4345
C-16	6500	10,730	3180	5090
C-18	7300	12,050	3645	5830
C-20	8000	13,200	4110	6575
C-22	8700	14,360	4575	7320
C-24	9300	15,350	5040	8065
C-26	9900	16,335	5450	8720
C-28	10,500	17,325	5800	9280
C-30	11,000	18,225	6110	9775

CAPITOL SQUARE SECTIONAL BOILERS



"50" Series
(All Fuels)

"50" Series—All Fuels

Boiler No.	Capacity Square Feet		Direct Cast Iron Radiator Loads Sq Ft	
	Steam	Water	Steam	Water
950	8800	14,080	5640	9025
1050	10,235	16,380	6560	10,500
1150	11,600	18,555	7435	11,895
1250	12,950	20,715	8300	13,280
1350	14,260	22,815	9140	14,625
1450	15,600	24,960	10,000	16,000
1550	16,910	27,060	10,840	17,345
1650	18,190	29,100	11,660	18,655
1750	19,435	31,100	12,460	19,935
1850	20,655	33,050	13,240	21,185

"WN" Series—All Fuels

WN-277	6060	9695	3885	6215
WN-278	7435	11,895	4765	7625
WN-279	8800	14,080	5640	9025
WN-280	10,235	16,380	6560	10,500
WN-281	11,600	18,555	7435	11,895
WN-282	12,950	20,715	8300	13,280
WN-283	14,260	22,815	9140	14,625
WN-284	15,600	24,960	10,000	16,000

"WNO" Series—For Oil Firing

WN-0277	6640	10,620	4935	7895
WN-0278	7640	12,225	5680	9090
WN-0279	8640	13,825	6425	10,280
WN-0280	9645	15,425	7170	11,470
WN-0281	10,640	17,020	7910	12,655
WN-0282	11,800	18,885	8775	14,040
WN-0283	12,920	20,670	9605	15,370
WN-0284	14,060	22,500	10,455	16,730
WN-0285	15,200	24,315	11,300	18,080
WN-0286	16,320	26,115	12,135	19,415
WN-0287	17,435	27,900	12,965	20,745
WN-0288	18,560	29,695	13,800	22,080
WN-0289	19,675	31,485	14,630	23,410

LITERATURE UPON REQUEST

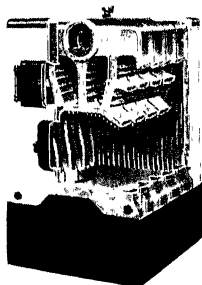
UNITED STATES RADIATOR CORPORATION

General Offices: Detroit, Michigan

Branches and Sales Offices in Principal Cities

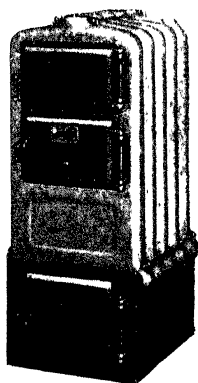
Detroit, Michigan

CAPITOL SUNRAY No. 9 SERIES BOILERS For Automatic Firing



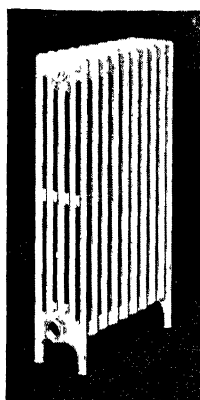
Boiler No.	Capacity Square Feet		I-B-R Sq Ft Direct Cast Iron Radiation	
	Steam	Water	Steam	Water
9-4	1360	2175	925	1480
9-5	1785	2855	1245	1990
9-6	2210	3535	1565	2500
9-7	2630	4205	1885	3020
9-8	3055	4885	2205	3530
9-9	3480	5565	2525	4040

"DEEPIRE" HOT WATER SUPPLY BOILERS Coal Fired



Boiler No.	Capacity—Gallons		
	100° Rise 6 Hours	85° Rise 1 Hour	100° Rise 1 Hour
30	792	155	132
40	1512	297	252
50	2160	423	360
60	2700	529	450

*CAPITOL THINTUBE RADIATORS

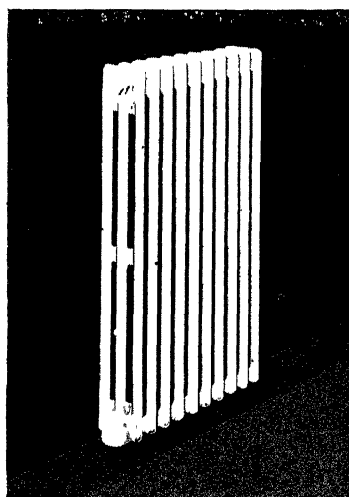


3-Tube	
Heights	Per Section Heating Surface
25"	1.6 Sq Ft
4-Tube	
19"	1.6 Sq Ft
22"	1.8 Sq Ft
25"	2.0 Sq Ft
5-Tube	
22"	2.1 Sq Ft
25"	2.4 Sq Ft
6-Tube	
19"	2.3 Sq Ft
25"	3.0 Sq Ft
32"	3.7 Sq Ft

*18 in Centers.

40 per cent less space needed for these graceful, efficient Capitol ThinTube Radiators

U. S. THINTUBE WALL RADIATOR



This Thintube Radiator has been designed for wall hung application. The narrow width of $3\frac{1}{4}$ in. and over-all height of 24 in. readily permits substitution for the heavier type conventional wall radiator, the production of which has been restricted by the War Production Board.

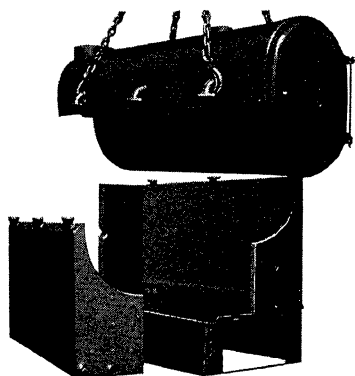
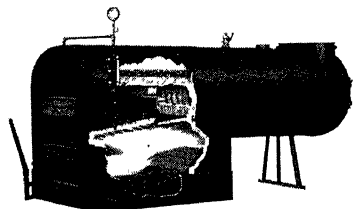
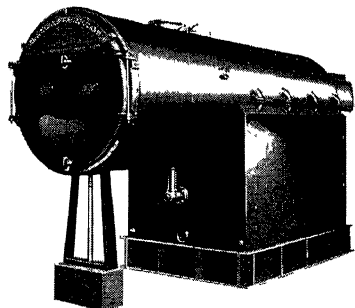
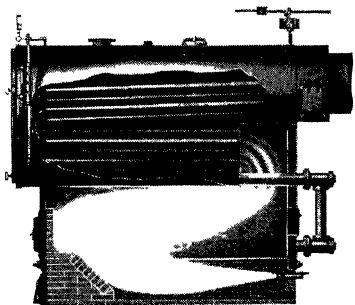
LITERATURE UPON REQUEST

Pacific Steel Boiler Division United States Radiator Corporation

General Offices: Detroit, Michigan

Sales Offices in Principal Cities

A Complete Line of Low Pressure Steel Heating Boilers



All Pacific Boilers are built using the A.S.M.E. Boiler Code Standards as minimums.

LOW WATER LINE SERIES

Built in the following capacities for steam:
Coal Burning Sizes—1800 to 35,000 sq ft.
Mechanically Fired Sizes—2680 to 42,500 sq ft.

High Fire Box for Stoker Firing—Sizes—2680 to 42,500 sq ft.

All Pacific Boilers are built, inspected, and tested under the supervision of the Hartford Steam Boiler Inspection and Insurance Company.

TWO-PASS FRONT SMOKE OUTLET

Built in the following capacities for steam:
Coal Burning Sizes—4000 to 30,000 sq ft.
Mechanically Fired Sizes—4860 to 42,500 sq ft.

All Pacific Boilers are made of steel with each joint and seam electrically arc-welded—built to last a life-time.

SINGLE-PASS REAR SMOKE OUTLET

Built in the following capacities for steam:
Coal Burning Sizes—1800 to 6000 sq ft.
Mechanically Fired Sizes—2190 to 7290 sq ft.

PACIFIC THREE-PIECE CONSTRUCTION

Made up of three parts, shell, firebox and base, Pacific Boilers are particularly adaptable to replacement work. Where necessary Pacific fireboxes can be split (as illustrated) allowing the boiler to be taken into the building in four pieces and erected without welding on the job.

Descriptive Bulletins on Pacific Steel Boilers will be mailed on request.

Weil-McLain Company

Manufacturing Division: Michigan City, Ind. and Erie, Pa.

General Offices: 641 W. Lake Street, Chicago

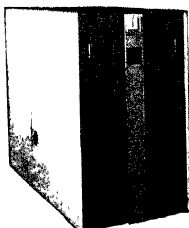
NEW YORK OFFICES: 501 Fifth Avenue

Prompt Weil-McLain Boiler and Radiator service is made conveniently available through local stocks carried by Weil-McLain Distributors in most of the important distributing centers.



**No. 68 Boiler
for Automatic Firing**

Boiler is completely jacketed and insulated. Has an integral front burner extension. Net I-B-R Ratings: Steam 390 to 690 sq ft, Water 625 to 1,100 sq ft.



**No. 78 Boiler
for Automatic Firing**

Boiler has insulated enameled de luxe jacket. Front or rear jacket extension available. Net I-B-R Ratings: Steam 530 to 1,130 sq ft, Water 850 to 1,810 sq ft.



**New No. 57
All-Fuel Boiler**

Jacketed and insulated square boiler for small homes. Net I-B-R Ratings: Steam 210 to 430 sq ft, Water 340 to 690 sq ft.



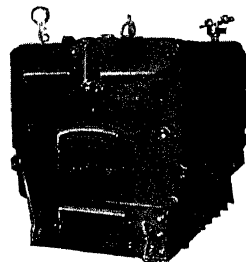
**No. 67—No. 77
All-Fuel Boilers**

Conversion type boilers with insulated enameled jacket. For hand or automatic firing. Net I-B-R Ratings: Steam 290 to 620 sq ft, Water 465 to 990 sq ft.



Round-Type Boiler

Unjacketed Round Boiler with corrugated heating surfaces for economical home heating. Connected Load Ratings: Steam 275 to 1,000 sq ft, Water 440 to 1,600 sq ft.



Square-Type Boilers

Sectional boilers for larger installations. Complete range of sizes. Connected Load Ratings: Steam 1,790 to 11,300 sq ft, Water 2,870 to 17,900 sq ft.



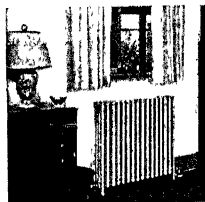
Raydiant "Concealed"

A Raydiant convector type all cast-iron Radiator. Made in "Concealed," also Partially Recessed, Cabinet and Humidifying types.



Solray Radiator

Free standing Cabinet type Radiator in a lower price range than Raydiant Cabinet Radiators. Available in three depths in 21, 24 and 27 in. heights.



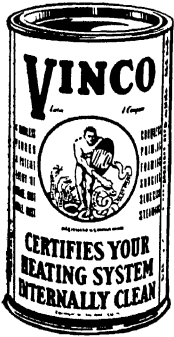
Junior Radiator

Smaller Tubular type Radiation which conserves space. Available in 1¼ in. centers in 3, 4, 5 and 6 tube widths and 13 to 32 in. heights.

The Vinco Company, Inc.

305 East 45th Street

New York, N. Y.



Boiler Cleanser
3, 5 and 10 lb cans

In peace or war, *only a clean boiler can be an efficient boiler.* Every pound of fuel saved by more efficient economical operation contributes to shortening and winning the war. A clean boiler means fuel saving—and fuel saving is now a patriotic duty.

VINCO BOILER CLEANSER

A positively harmless insoluble powder cleaner for new, remodeled and old heating systems. A unique, scientifically processed compound on a special formula not to be confused with other powder boiler cleaners.

What Vinco Boiler Cleanser Does

VINCO removes oil, grease, scale, rust and dirt from the internal surfaces and from the boiler water *without the labor, expense, and uncertain results of blowing boilers over the top or of wasting returns.*

By this thorough cleaning Vinco prevents or cures foaming, priming, surging, and slow steaming.

How Vinco Boiler Cleanser Works

Each minute grain of VINCO powder adsorbs several times its own weight of oil, rust and dirt. These larger grains of adsorbed impurities then settle and are drained through the bottom according to directions on each can.

Our Guarantees

1. VINCO contains no potash, lye, soda of any kind, oil, acid, or other harmful ingredients.
2. Purchase price is refunded if results are not as claimed when VINCO has been used according to directions.

VINCO RUST PREVENTER

When used after VINCO Boiler Cleanser has removed oil, grease, rust, scale and dirt, it will keep the rust inhibiting factors at the optimal constant for a year or more. (Testing kit below has complete instructions and chart.)

VINCO TESTING KIT No. 10

for Testing Heating Boiler Waters

The kit enables the layman to make simple, rapid tests to diagnose and prescribe correct treatment of boiler waters right on the job.

A new time saving method that permits valid conclusions heretofore requiring complicated and often lengthy laboratory analysis and technique.

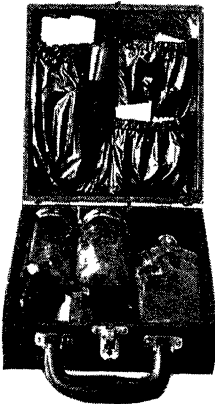
Each kit has sufficient material for complete tests on 100 jobs.

Refills cost about 2 cents per test.

Help Win the War by Fuel Saving.



Rust Preventer
1 qt cans only



Vinco Testing
Kit No. 10
(Patent applied for)

VINCO SOOT-OFF

Safely and thoroughly removes the insulating blanket of soot on fire pot, flues and chimney. It also insures against external corrosion (caused by dampness and soot forming sulphuric acid during summer layoff.) No dangerous chemicals.

VINCO SUPERFINE LIQUID BOILER SEAL

A different liquid seal. Unique in that it does not induce priming and foaming. It has no unpleasant smell. Makes speedy and permanent repairs of boiler and heating system leaks. Fine to tighten up new jobs. Directions simple.

Quantities

Steam and Vapor Systems—Use 1 quart VINCO Liquid Boiler Seal to each 6 sq. ft. grate area.

Hot Water Systems—Use 2 quarts VINCO Liquid Boiler Seal to each 6 sq ft grate area.

SPECIFICATIONS FOR COMPLETE VINCO Treatment of New or Remodeled Steam or Vapor Heating Systems

QUANTITIES OF VINCO (IN POUNDS) REQUIRED FOR HEATING SYSTEMS

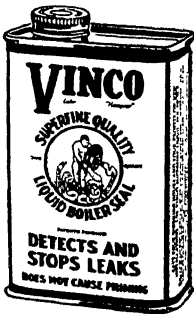
(Note that quantities are based on actual installed radiation, not on boiler capacity.)

Sq Ft of Radiation	For Steam or Vapor Systems, to prevent or cure priming or foaming. Also for Hot Water Heating Systems installed at approx 200 F or above.	Annually, to remove rust scale, dirt and for Hot Water Systems below 200 F.
up to 350	3	1 1/2
351 " 600	5	2 1/2
601 " 1100	8	4
1101 " 1400	10	5
1401 " 1800	13	6 1/2
1801 " 2100	15	7 1/2
2101 " 2700	18	9
2701 " 3100	20	10
3101 " 3700	23	11 1/2
3701 " 4200	26	13
4201 " 4600	28	14
4601 " 5000	30	15
5001 " 5300	31	15 1/2
5301 " 5600	32	16
5601 " 5900	33	16 1/2
5901 " 6200	34	17
6201 " 6500	35	17 1/2
6501 " 6800	36	18
6801 " 7100	37	18 1/2
7101 " 7400	38	19
7401 " 7700	39	19 1/2
7701 " 8000	40	20
8001 " 8300	41	20 1/2
8301 " 8600	42	21
8601 " 8900	43	21 1/2
8901 " 9200	44	22
9201 " 9500	45	22 1/2
9501 " 9800	46	23
9801 " 10100*	47	23 1/2

*Above 10100 sq ft use an additional pound Vinco for each additional 300 sq ft of actual installed radiation.



Soot-Off—1 lb cans 50 and 100 lb drums



Liquid Boiler Seal 1 qt. cans only

Do not use as a cleaning agent soda or any alkali, vinegar or any acid. Use Vinco.

1. After the system is tested and tight, use the proper quantity of Vinco listed. After this first clean-out of any new or remodeled heating system, Vinco Boiler Cleaner need be used only if more piping, radiation, or another boiler is added to the original installation.

2. After using Vinco Boiler Cleaner, Vinco Field Test Kit should be used to determine and apply the proper quantity of Vinco Rust Preventer. Vinco Rust Preventer should be applied annually or whenever the boiler water is drained for necessary repairs to the system.

SPECIFICATION FOR OLD HEATING SYSTEMS THAT DO NOT PERFORM PROPERLY

Diagnose and treat according to Vinco Field Test Kit.

SPECIFICATION FOR HOT WATER SYSTEMS

Use half quantities listed for treatment of steam systems to remove impurities. Then use test kit to determine proper quantity of Vinco Rust Preventer.

REMOVE SOOT WITH VINCO SOOT-OFF SEVERAL TIMES A YEAR

The Webster Engineering Co.

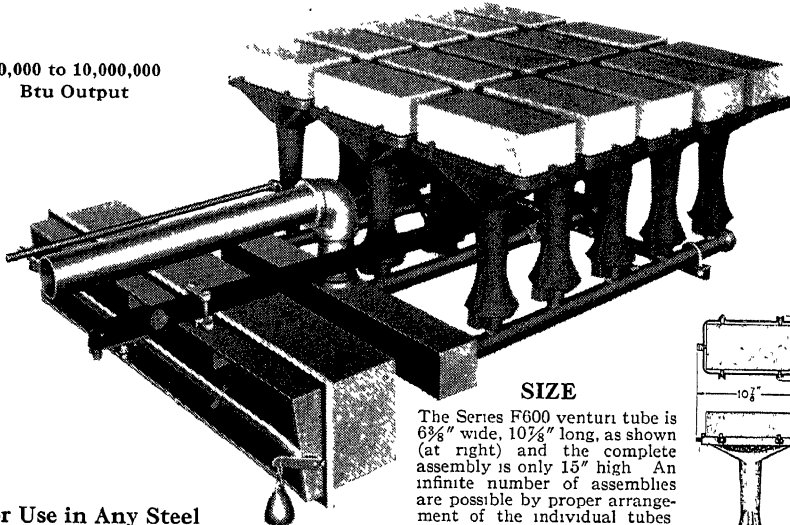
419 West 2nd St., Tulsa, Oklahoma

Division of

SURFACE COMBUSTION, TOLEDO, OHIO

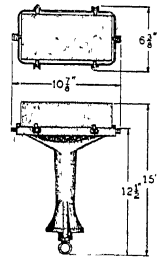
WECO-N.G.E. SERIES F600 GAS BURNERS

50,000 to 10,000,000
Btu Output



SIZE

The Series F600 venturi tube is $6\frac{1}{8}$ " wide, $10\frac{1}{2}$ " long, as shown (at right) and the complete assembly is only 15" high. An infinite number of assemblies are possible by proper arrangement of the individual tubes. For complete sizing information see Bulletin F600H.



For Use in Any Steel Firebox or Sectional Boiler

Improved venturi and greater port area insure much higher capacities at lower pressures.

Unique baffles at the outlet of the mixing tube make possible perfectly even distribution of flame completely around the baffle brick. As a result the maximum flame length is greatly reduced.

Interchangeable grills with multiple ports can be varied to suit the combustion characteristics of various gases. The proper sizing of these grills prevents any possibility of flash back.

In addition to the above major improvements the F600 possesses the same desirable features that made the 600 so popular.

1. Simple installation requiring no expensive insulated combustion chamber and having no furnace radiation loss.

2. Extreme quietness due to low rate of

combustion over a large area

3. Flexibility from infinite number of possible combinations varying both size and shape to meet load and firebox conditions at various gas pressures.

4. High radiant transmission rate due to radiant temperature of the standard fire-brick baffles on the top of the burner tubes.

5. Low draft loss because of ample secondary air openings.

6. Plain gas pilots of heat resistant material and of a design that will not allow flame to pull off.

7. Safety pilot applied in a cool zone in a manner that insures perfect direct ignition of the burner yet allowing the thermal element to cool quickly upon flame failure.

8. Guaranteed vibrationless under all conditions.

CAPACITY OF SINGLE F600 VENTURI TUBE—No. 17 MTD ORIFICE

Manifold Gas Pressure	0.5" W.C.	1.0" W.C.	2.0" W.C.	3.0" W.C.	4.0" W.C.	5.0" W.C.	6.0" W.C.	4 oz. W.C.	6 oz. W.C.	8 oz. W.C.
Input—Cu Ft, 1 hr.	24.5	38.5	58.0	72.0	84.0	94.5	104.0	112.0	138.0	159.5
Output—Sq Ft, St. Rad.	75	117	178	222	258	289	318	343	423	488
Output—Boiler H.P..	.54	.84	1.23	1.59	1.85	2.07	2.28	2.46	3.04	3.4

TODD COMBUSTION EQUIPMENT, INC.

(Division of Todd Shipyards Corporation)

601 West 26th Street, New York City

NEW YORK MOBILE NEW ORLEANS GALVESTON SEATTLE BUENOS AIRES LONDON



The TODD HEX-PRESS REGISTER in combination with the TODD "VEE-CEE" VARIABLE CAPACITY BURNER

Makes possible increased combustion efficiency under almost any type of boiler of 100 H.P. capacity or larger, operating at 50 pounds steam pressure or higher.

It provides equal efficiency under either forced or natural draft conditions. The Hex-Press Register assures the most intimate mixture of oil and air as well as quicker, more complete combustion . . . with minimum draft loss at high capacity . . . effecting great economy in main-

tenance and materially reducing fuel costs.

Through the exclusive "variable range" feature of the "Vee-Cee" Burner, practically unlimited firing range is assured . . . without change of burner tips, oil delivery pressure or angle of spray.

Constant steam pressure can be maintained regardless of demand . . . changing load requirements are met instantly under manual or fully automatic control.

COMBINATION GAS and OIL BURNERS

For Natural or Refinery Gas and/or Fuel Oil. Available in wide range of capacities. Quickly adjustable for the combustion of either fuel alone, or both in combination. Of special value where fluctuating comparative costs of these fuels call for equipment suited to changeover without time-consuming structural changes.

Maintenance and operation are reduced to a minimum by compactness and simplicity of design . . . accessibility of all parts . . . rugged construction and positive

overall efficiency.

Design features eliminate possibility of escaping gas due to structural distortion . . . prevent stratified combustion resulting from improper air distribution and high gas pressure.

Providing sufficient flexibility to care for varying loads, these units assure high furnace temperature and radiant heat transfer with low stack temperature . . . thorough mixture and optimum air-fuel ratio with utmost ease of adjustment.

ROTARY FUEL OIL BURNERS

For firing high or low pressure steam or hot water boilers of all types . . . in smaller factories and industrial plants, laundries, dryers and cleaners, office buildings, hotels, apartment houses. Also applicable to industrial ovens, kilns, etc., where furnace and general physical conditions permit.

Available with manual, semi-automatic or fully automatic control . . . in varying sizes and types . . . for burning light or heavy oil.

Horizontal atomizing cup is rotated by direct-connected electric motor, assuring

constant firing as long as motor is in operation. Motors are of extra large frame size, air-cooled and built to withstand long, hard service. Positive air-oil interlocking device automatically shuts off oil supply following any burner stoppage.

Of rugged construction . . . with all parts easily accessible for cleaning or renewing . . . these burners provide a flexible capacity range, with complete and efficient combustion under widely fluctuating loads.

TODD MANUFACTURES: Mechanical Pressure Atomizing Oil Burners—VEE-CEE Variable Capacity Burners—Horizontal Rotary Oil Burners—Oil Burning Air Registers for Natural, Assisted, Induced or Forced Draft—Inside Mixing Steam Atomizing Oil Burners—Combination Gas and Oil Burners—Furnace Doors and Interior Castings for converting Howden Type Furnace Fronts to oil firing—Oil Burning Galley Ranges—Oil Heating, Pumping and Straining Equipment.

All installations of Todd Equipment are always individually engineered to fulfill specific requirements. Send for descriptive literature.

Todd engineers are always available for consultation and analysis of combustion problems—without obligation.



The Brownell Company

ESTABLISHED 1855

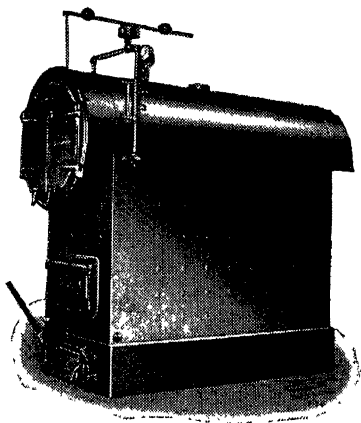
Dayton, Ohio

Manufacturers of

BROWNELL BOILERS AND STOKERS

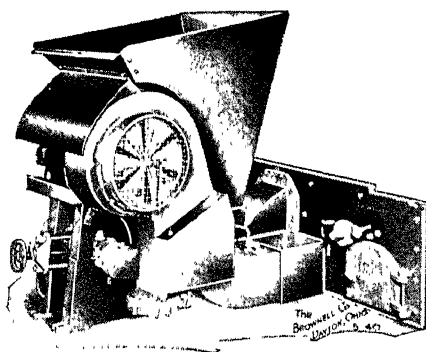
Representatives in All Principal Cities

FIRE TUBE BOILERS of various types. **HEATING BOILERS** riveted and welded. **UNDERFEED STOKERS** from 5 Horse Power upwards **STEEL STACKS, TANKS AND SPECIAL PLATE WORK.**

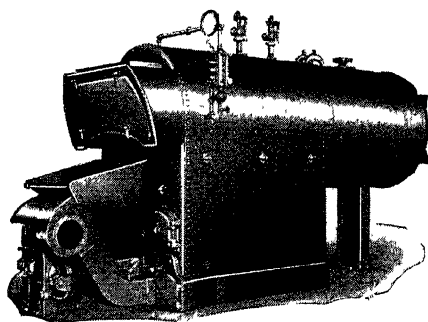


Type L R (Low Set) Underfeed Ram Type Stoker with automatic air volume control. Can be furnished with Brownell exclusive, fully automatic coal feed control. Sizes up to 300 horse power. An ideal stoker for firebox boiler or other installations where height of setting is limited.

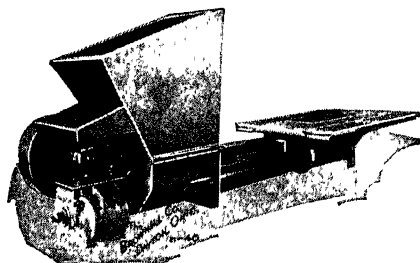
Welded Triple Pass Heating Boilers built in either high leg or low water line types. Hand fired ratings 500 to 35,500 sq. ft. steam, 800 to 56,800 sq. ft. water radiation. Stoker, Oil or Gas fired up to 43,100 sq. ft. steam or 69,000 sq. ft. water radiation. A.S.M.E. Code construction.



High or Low Pressure Double Pass Boiler with Type L R Stoker. Designed and manufactured as a matched unit steam generating plant. Furnished in working pressures from 15 to 150 pounds and sizes up to 300 horse power. For power, heating and process steam. Steam ratings 3,600 to 42,500 sq. ft. Water rating 5,800 to 68,000 sq. ft. when used with stoker, oil or gas. A.S.M.E. Code construction.



Type C Screw Feed Stoker, proved by years of service to be sturdy, reliable and efficient. Illustration shows dead plates can also be furnished with dump plates in the larger sizes. 30-300 HP.



The illustrations above show only a part of the complete Brownell line. We shall gladly send literature describing **BROWNELL BOILERS AND STOKERS.** Our nation wide field organization is ready to assist in problems of steam generation.

Combustion Engineering Company, Inc.

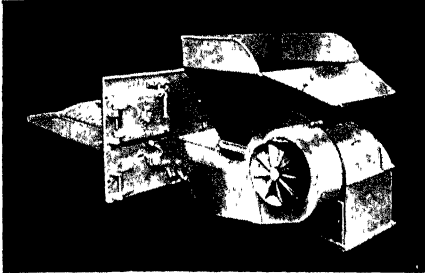
All Types of Fire Tube and
Water Tube Boilers
Mechanical Stokers



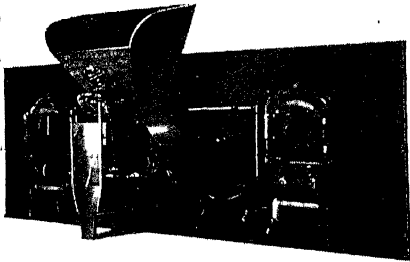
Complete Steam Generating Units
Pulverized Fuel Systems

200 Madison Avenue, New York, N. Y.
Offices in all principal cities of the United States and Canada

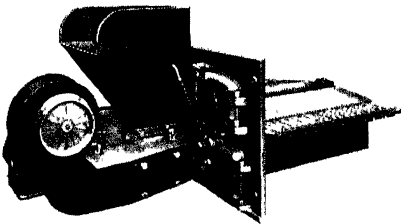
More than 17,000 C-E Stokers purchased to date



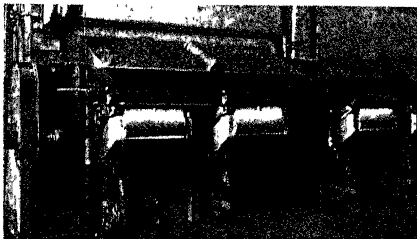
C-E Skelly Stoker Unit



Type E Stoker



C-E Low Ram Stoker



C-E Spreader Stoker

C-E Skelly Stoker Unit—A compact, self-contained unit with integral forced-draft fan, adapted to burn either anthracite or bituminous coal. Alternate fixed and moving grate bars assure lateral distribution of fuel. Automatic control is standard equipment. Approximate application range—20 to 200 rated boiler hp.

Type E Stoker—A single-retort, underfeed stoker with an established reputation of many years' standing for dependable service. Designed to burn a variety of bituminous coals under boilers up to about 600 rated hp. Available with steam, electric or hydraulic drive.

C-E Low Ram Stoker—A single-retort, stationary-grate underfeed stoker for burning bituminous coals under boilers in the upper size range of the C-E Skelly Stoker.

C-E Spreader Stoker—A simple, rugged overfeed stoker designed to burn a wide variety of coals. Fines are burned in suspension and the coarser coal on a grate which may be of either stationary or dumping type. Rate of coal feed and air supply may be regulated over a wide range and are readily adaptable to automatic control. Applicable to boilers from about 100 boiler hp up.

C-E Multiple Retort Stoker—For burning bituminous and semi-bituminous coals under boilers up to the largest sizes.

C-E Traveling Grate and Chain Grate Stokers—Including both Coxé and Green types. Available with grate surfaces suitable for anthracite, coke breeze, lignite or bituminous coal, as required. Traveling grates are all forced-draft types; chain grates are either forced or natural draft types.

C-E Boilers—All fire tube and water tube types in sizes ranging from 25 hp up to the largest. Standard and special designs to suit all conditions of fuel, load and space. Included are all types formerly known by the trade names "Heine," "Walsh & Weidner," "Casey-Hedges," "Ladd" and "Nuway".

Separate Catalogs describing each of these stokers are available. A-531-B

Detroit Stoker Company

Sales and Engineering Offices
General Motors Bldg., Detroit, Mich.



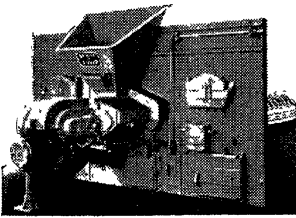
District Offices in
Principal Cities

Main Offices and Works at Monroe, Mich.

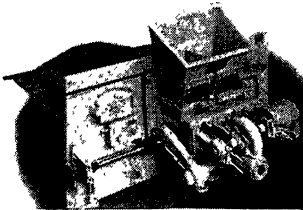
Since 1898

Built in Canada at London, Ont.

Detroit Stokers are unsurpassed for economy and dependability. They include Underfeed and Overfeed Stokers of many sizes and capacities for all types of boilers, 30 Horse Power and upwards. All grades of Bituminous Coal successfully burned. Operating costs are low. Substantial, heavy designs represent over forty years' experience in Stoker manufacture. Catalogs of various types, furnished on request.



Detroit C-D Stoker is a Single Retort, Moving Grate Stoker with Continuous Ash Discharge.



Detroit Double Retort Stoker, a multiple retort side cleaning stoker for medium size boilers.



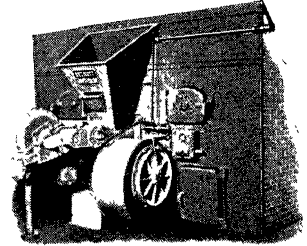
Detroit RotoStoker, (Stationary Grate Type). Ash removed through doors at grate level successfully burns a wide range of fuels.

Detroit UniStoker with Detroit Adjustable Feed (Coal Feed Control) insures accurate fuel and air supply for best economy. Single Retort, Side Cleaning, for boilers approximately 125 to 250 horsepower.

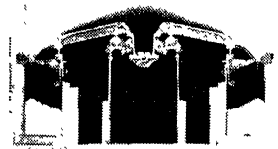
C-D Stoker—Single Retort, Moving Grate Stoker. Continuous Ash Discharge Sections at each side have a rocking movement. Rate of ash discharge, controlled at the front. Ash pit losses are low. Motor or steam ram driven. For boilers of approximately 300 to 500 Horse Power.

Detroit Double Retort Stoker, a Multiple Retort Stoker having two retorts with the side cleaning feature. For medium sized boilers having wide furnaces. Used to advantage where limited space conditions prevent the use of the rear cleaning Multiple Retort Stoker.

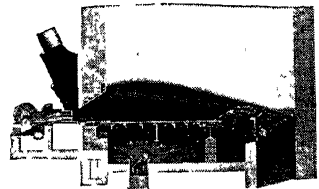
Detroit RotoStokers are Overfeed Spreader Type Stokers, having an Overthrow Rotor action, which insures uniform fuel distribution over the entire area. Offers advantages over other firing methods for burning inferior fuels and efficiently handling extremely fluctuating loads.



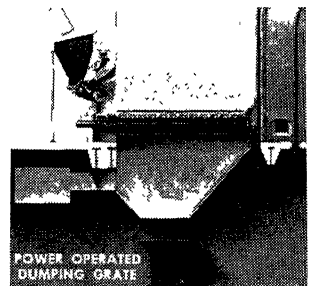
Detroit UniStoker with Detroit Adjustable Feed provides a wide range of coal feed control.



Detroit C-D Stokers. C-D stands for Continuous Discharge of Ashes



Detroit Multiple Retort Stoker for large boilers and high capacities. An inclined fuel bed Stoker, possessing all outstanding modern features



Detroit RotoStoker (Dumping Grate Type) (Either Power or Hand Operated) for large boilers. Particularly suited to fluctuating loads

DETROIT LOSTOKER

Detroit LoStoker is a complete mechanical firing unit in many grate area sizes and capacities for application to all types of boilers from approximately 30 to 150 hp. Burns various grades of Bituminous Coal with high efficiency. Fuel is fed only when needed—none wasted. Single Retort, Side Cleaning, Adjustable Plunger Feed Type, mechanically driven from electric motor, requires little power for operation. Automatically controlled from steam pressure, water temperature or room thermostat. Compact, easily installed, responsive and automatic. A great coal saver.

ADVANTAGES:

Continuous Adjustable Plunger Feed with control of the quantity of coal fed and its distribution

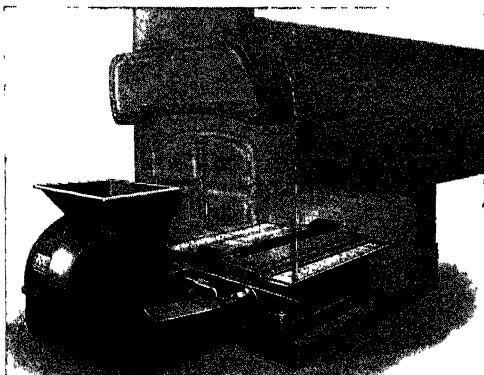
Heavy Mechanical Drive of simple design, requires little power.

Side Cleaning with dumping grates, ashes removed through doors provided in the Stoker front. No hand cleaning.

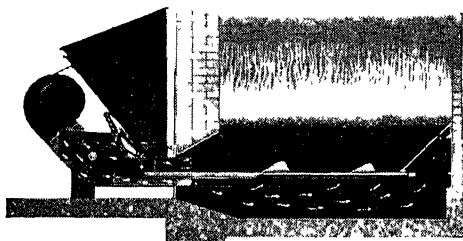
Agitator in coal hopper for continuous coal feed, cannot stick or jam with wet coal.

Automatically Controlled. Motor or steam turbine driven, controlled from steam pressure, water temperature or thermostat.

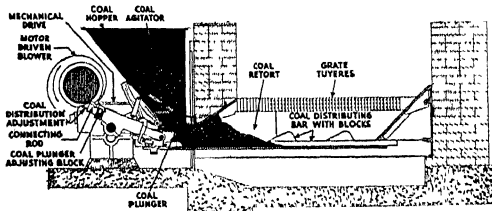
Many grate area sizes and capacities to fit the furnace and provide the proper grate area to readily handle heavy loads and also to operate efficiently under light load conditions.



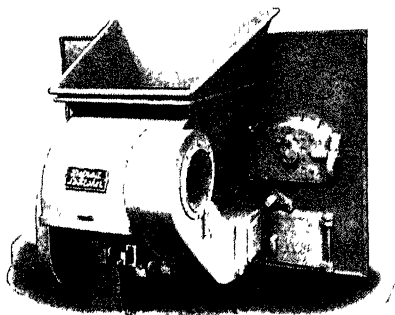
Detroit LoStoker readily applied to Firebox Boilers—built to fit the Furnace or Firebox. Coal Hopper with Agitator designed to clear Boiler Doors. Plunger Feed-side cleaning feature eliminates arduous hand cleaning of fires



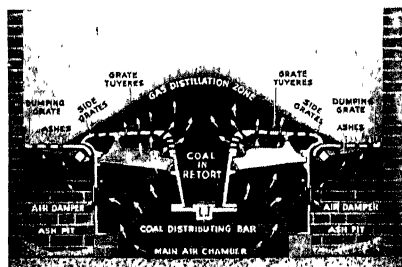
Detroit LoStoker (Side elevation in brick setting) for horizontal return tubular or water tube boilers.



Detroit LoStoker showing adjustable plunger feed



Detroit LoStoker (brickset type) for application to horizontal return tubular or water tube boilers.



Front Elevation of Detroit LoStoker (brickset type) built to fit the furnace. For use with horizontal tubular, firebox boilers on brick foundations or water tube boilers. Arrows indicate flow of air to fuel bed

Iron Fireman Manufacturing Company

Automatic Coal Stokers



Portland, Oregon

Cleveland, Ohio

Address inquiries to 3369 West 106 St., Cleveland, Ohio

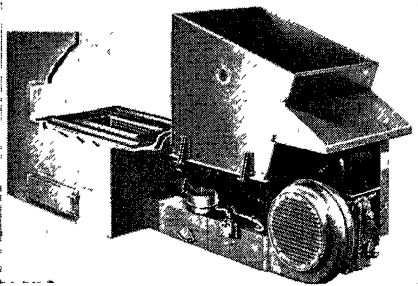
Retail Branches or Subsidiaries: CHICAGO, ILL.; MILWAUKEE, WIS.; ST. LOUIS, MO.; NEW YORK, N. Y.; BROOKLYN, N. Y.; TORONTO, CANADA; MONTREAL, CANADA

Dealers in Principal Cities and Towns in the United States and Canada

Representation in numerous foreign countries

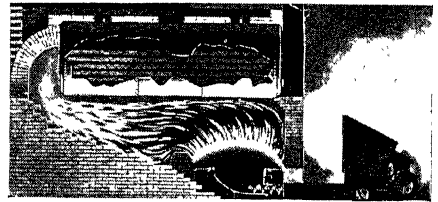
COMMERCIAL AND INDUSTRIAL STOKERS

STANDARD HOPPER MODELS



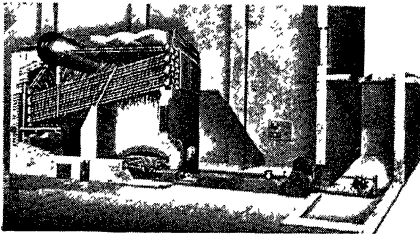
Commercial Installation—Hopper Model

This series of stokers is the standard of value in equipment for automatically firing boilers ranging in size up to 350 horsepower. Available in a wide range of coal feeding capacities, lengths and grate arrangements, to fit varied requirements.



Hopper Model Iron Fireman in Operation in Horizontal Return Tubular Boiler

STANDARD COAL FLOW MODELS



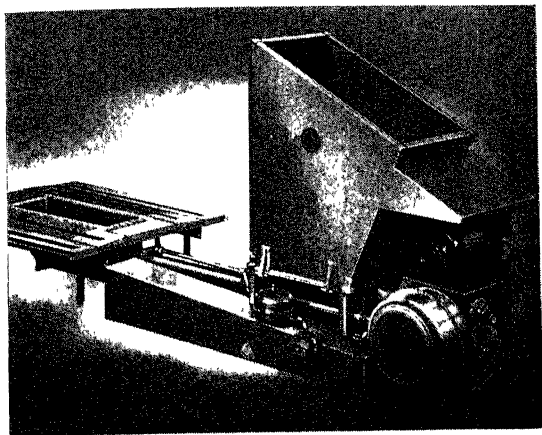
Commercial—Industrial Installation—Coal Flow model that carries coal direct from bunker to fire

A heavy duty stoker which combines Iron Fireman's well known firing efficiency with the automatic conveying of coal direct from bunker to fire. An integral coal conveying mechanism eliminates the labor and expense of manual coal handling. The Iron Fireman Commercial-Industrial Coal Flow stoker fires boilers developing up to 350 horsepower. Pneumatic Spreader stokers also available in Coal Flow models.

MODEL	OUTPUT RANGE		
	Boiler Horsepower	Equivalent Direct Radiation	
		Steam (240 Btu)	Hot Water (150 Btu)
Coal Flow (available in all models)	3 to 500*	400 to 70,000	650 to 110,000
Commercial and Industrial Standard Underfeed	3 to 350	400 to 50,000	650 to 75,000
Commercial and Industrial Poweram Underfeed	30 to 400	4,000 to 56,000	6,000 to 90,000
Commercial Anthracite	30 to 130	4,000 to 18,000	6,000 to 29,000
Pneumatic Spreader	50 to 1,000*	7,000 to 140,000	11,000 to 225,000

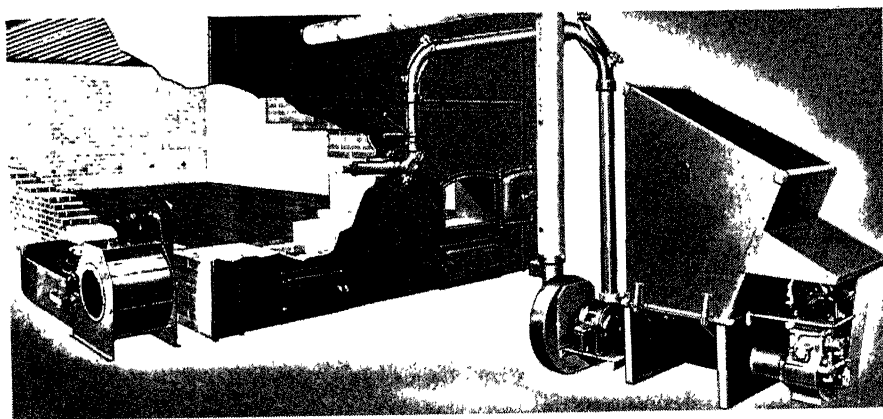
*Multiple units available for larger boilers.

POWERAM STOKERS



Combines ram-type coal distributor system in retort with free-running worm conveyor from coal supply, and has these advantages: Delivers the fuel to the fire bed in a loose, easily aerated condition; the reciprocating pusher blocks insure proper fuel distribution, and make possible the successful and efficient burning of many types of coal which otherwise are impractical to fire automatically. Designed for boilers developing up to 400 horsepower.

PNEUMATIC SPREADER STOKERS



As shown in the illustration above, the Iron Fireman Pneumatic Spreader stoker conveys coal from the hopper or main coal bunker to a transfer housing, where it is picked up by a stream of air and carried to the furnace and grates. The fines burn in suspension, and the larger pieces form a shallow fuel bed on the grate. By means of an adjustable nozzle, the coal is distributed uniformly over the entire grate surface. The conveying air provides the overfire air which is essential for efficient combustion. Entering at right angles to the flow of burning gases from the fuel bed, the conveying air produces *maximum turbulence*; another requisite of efficient and smokeless combustion. The Iron Fireman

Pneumatic Spreader stoker was designed to burn efficiently such economical fuels as the lower rank bituminous, and sub-bituminous coals and also lignite. It provides reliability of operation, physical adaptability, ease of operation, and low maintenance which is not afforded by other types of automatic coal burning systems. Pneumatic Spreader stokers are particularly adaptable to operation at high ratings, and as a result are greatly stepping up steam output in many plants throughout the United States and Canada. Iron Fireman Pneumatic Spreader stokers are made in both hopper and Coal Flow models; the latter carry coal direct from the bunker to the fire.

Buffalo Pumps, Inc.

450 Broadway, Buffalo, N. Y.

Branch Offices

ALBANY, N. Y., 1303 Standard Bldg., R. B. Taylor
ATLANTA, GA., 305 Techwood Drive, J. J. O'Shea
BALTIMORE, Md., 508 St. Paul St., E. E. Thompson
BOSTON, MASS., 507 Main St., Melrose Station, E. D. Johnson
CHICAGO, ILL., 20 N. Wacker Drive, L. D. Emmert
CINCINNATI, OHIO, Building Industries Bldg., F. W. Twombly
CLEVELAND, OHIO, 418 Rockefeller Bldg., T. A. Weager
DALLAS, TEXAS, 1801 Tower Petroleum Bldg.,

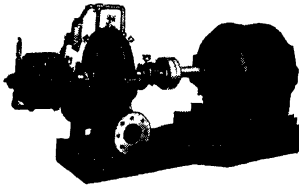
T. H. Ansbacher

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D. C. Murphy Co., Inc.
DENVER, COLO., 1718 California St., Stearns Roger Mfg. Co.
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NEW YORK, N. Y., 39 Cortlandt St., W. S. Koithan
OMAHA, NEBR., 660 N. 8th St., Russell Harris
PHILADELPHIA, PA., 702 Cunard Bldg., Davidson & Hunger
RICHMOND, VA., Williamson & Wilmer, Inc., Mutual Bldg.
SEATTLE, WASH., 500 First Ave., So., A. T. Forsyth
ST. LOUIS, MO., 1598 Arcade Bldg., J. W. Cooper
TOLEDO, OHIO, 1922 Linwood Ave., C. M. Eyster
WASHINGTON, D. C., 512 Woodward Bldg., G. S. Franke
COMPLETE LINE MANUFACTURED IN CANADA BY CANADA
PUMPS, LTD., KITCHENER, ONT

PRODUCTS—A complete line of Single and Multi-stage Centrifugal Pumps and Special Pumps for use in all types of heating and air conditioning installations.

Buffalo Self-Priming Single and Double Suction Centrifugal Pumps

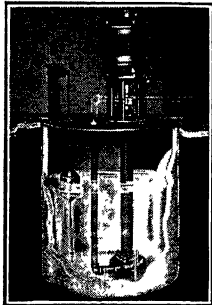


Now available with positive self-priming device built with the pump. This primer is built under license from the Nash Engineering Company and is fully covered by patent.

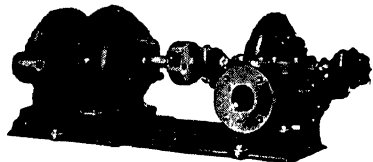
Buffalo Self-Priming Pumps offer these advantages: (1) All working parts are above the liquid to be pumped. (2) There is complete access to all parts of installation. (3) Rotors are balanced—vibrationless. (4) Buffalo Self-Priming Pumps are very quiet—no long shafts to vibrate and fewer bearings. (5) Constant positive prime obtained without foot valves.

Buffalo Automatic Sump Pumps

Buffalo Sump Pumps are self-contained and have unusually high efficiencies thus permitting the use of small motors. Ball bearing thrust and enclosed shaft especially adapt these pumps for their service.

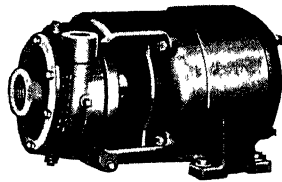


Buffalo Double Suction Single Stage Centrifugal Pumps



For general service where clear water is handled you will get top performance with these pumps. They embody all of the accepted modern features of centrifugal pump design. Capacities range from 10 to 50 thousand U.S. gallons per minute.

Buffalo Single Suction Closed-Coupled Pumps



This pump is close-coupled to electric motor, eliminating the necessity for bearings. The impeller is overhung on the motor shaft, providing a compact, easily-serviced unit. Permanent alignment is assured and the pump mounted in this manner requires very little space.

Buffalo Close-Coupled Pumps are suitable for handling hot water with low submergence on suction, or for operating with suction lift as high as 25 ft.

These pumps are also available in special alloys.

Chicago Pump Company

2330 Wolfram Street

BRUNSWICK 4110

Chicago

PRODUCTS—Return Line Vacuum Heating and Boiler Feed Pumps, Condensation, House, Booster, Fire Pumps, Circulating, Brine, Sewage, Bilge, Sludge, Pneumatic and Tankless Water Supply Systems and Automatic Alternator for Duplex Sets of Pumps.

"CONDO-VAC"

Return Line Vacuum and Boiler Feed Pump for Heating Systems

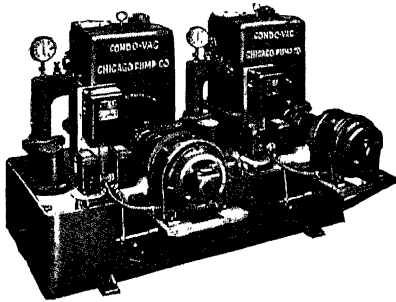


Fig. 2102—Duplex "Condo-Vacs" with Duplex Double Automatic Control

No vacuum on stuffing boxes, ample clearance in rotating member. It costs less to operate a "Condo-Vac." "Condo-Vac" reduces corrosion in piping and boiler to minimum—because pump does not take in air from atmosphere and entirely eliminates all air coming back from system. "Condo-Vac" is quiet, has a low inlet, entirely automatic, fool-proof, easy to maintain. Ask for bulletin 270.

Close-Coupled Pumps

Boiler Feed, Circulating, Tank Filling, Water Supply

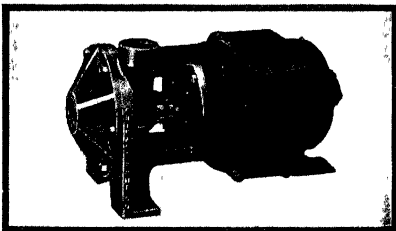


Fig. 2130—Close-Coupled, side suction pump Capacities range from 3 to 600 Gpm against heads up to 189 ft. Motors from 1/8 to 20 H.p. Discharge 1 to 3 in. Closed and open type impellers. Bulletin 108

"Sure-Return" Condensation Pump

for Low and Medium Pressure, and Systems up to 75,000 Sq Ft Radiation

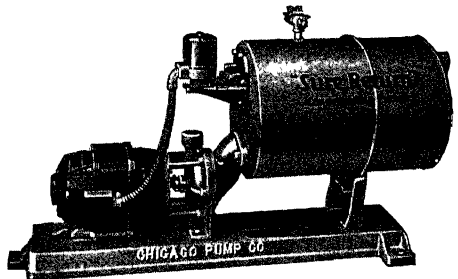


Fig. 1946

"Sure Return" Condensation Pumps and Receivers are built for systems up to 75,000 sq ft of direct radiation and for low and medium pressures. Built in either single or duplex units. Duplex units are alternated in their operation by the Automatic Alternator. Complete data in Bulletin 250.

Vertical Condensation Pumps

for Low and Medium Pressure for Systems from 500 to 100,000 Sq Ft Radiation

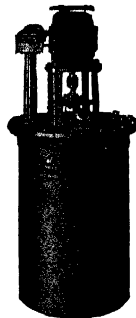


Fig. 1940 Vertical Condensation Pump

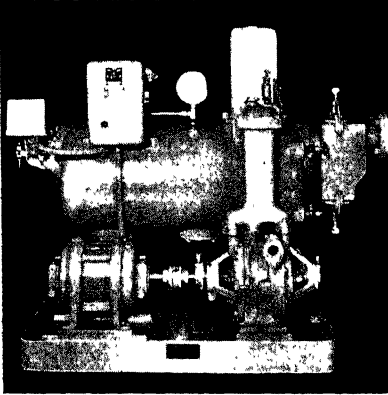
The vertical condensation pump is designed to receive returns from lowest radiation. The receiver is placed underground—an ordinary hole sufficing if necessary—and requires very little floor space. Unit is shipped complete, easy to install, assembled so as to prevent steam leaks. Special bearings will stand up under hot water for several years. A special float mechanism is guaranteed not to leak or stick in stuffing box. Complete data and description in Bulletins 245, 253 and 255.

The Nash Engineering Company

234 Wilson Road

South Norwalk, Conn., U. S. A.

Sales and Service Offices in all Principal Cities

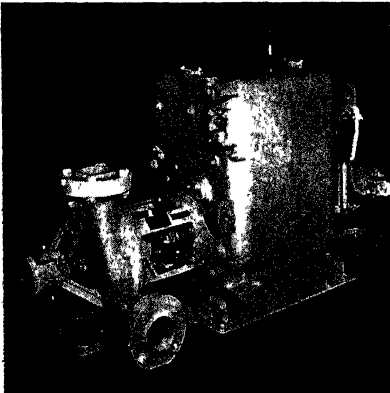


Return Line Vacuum Heating Pump

Standard with the heating industry for over seventeen years. Removes air and condensation from return lines of vacuum steam heating systems, discharging air to atmosphere and returning water to the boiler.

Two independent units are combined in a single casing—an air unit and a water unit. Impellers of both are mounted on the same shaft. Pump is bronze fitted throughout.

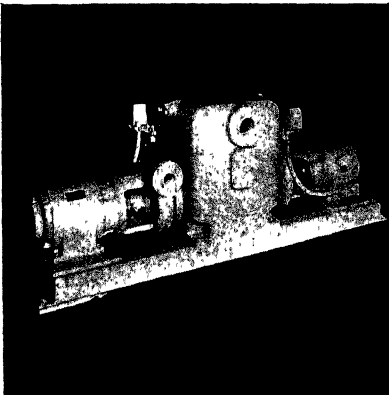
Supplied direct connected to standard electric motors, for belt drive, or for steam turbine drive. For continuous or automatic operation. Standard in capacities up to 300,000 sq ft E.D.R. Larger units special. Bulletin Nos. 307, 308, 309, and 310 on request.



Vapor Turbine Vacuum Heating Pump

Jennings Vapor Turbine Heating Pumps combine all advantages of the standard return line heating pump with a new type of drive, a specially designed low pressure turbine which operates directly on steam from the heating mains on any system, requiring a differential of only 5 in. of mercury, and returns that steam to the heating system with practically no heat loss.

This pump affords the safety and economy which goes with continuous condensation return and steady vacuum, and at no cost for electric current. Furnished standard in capacities up to 65,000 sq ft E.D.R. Larger units special. Bulletin No. 290 on request.



Condensation Pump and Receiver

Removes the condensation from radiators in return line steam heating systems, particularly radiators set below the boiler water line level, and pumps the condensation back to the boiler. Pump is bronze fitted with enclosed centrifugal impeller of improved design. By making the pump casing a part of the return tank, and bolting the motor base to the tank, floor space is conserved. The rectangular construction permits installation in a corner against the wall.

These pumps are furnished in standard sizes with capacities ranging from 1½ to 225 gpm of water. For serving up to 150,000 sq ft of equivalent direct radiation. Bulletin No. 319 on request

The Nash Engineering Company

234 Wilson Road

South Norwalk, Conn., U. S. A.

Sales and Service Offices in all Principal Cities

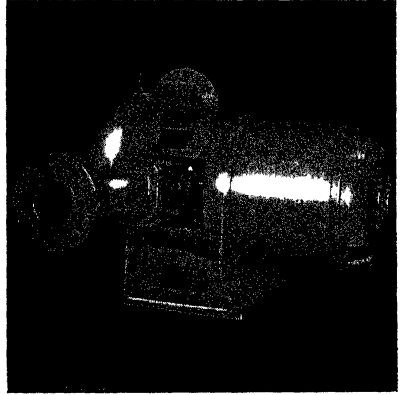
Centrifugal Pump

Made in standard and suction (self-priming) types. For circulating hot and cold water; boosting city water pressure; handling water in air washing and conditioning; handling ash sluicing water, etc.

Compact—motor armature and pump impeller are mounted on the same shaft. Simplified—no bearings in pump casing, one stuffing box. Accessible—impeller removable without disturbing piping or shaft alignment.

Self-priming types will handle air or gas continuously with liquid being pumped, and can be operated intermittently without foot valve.

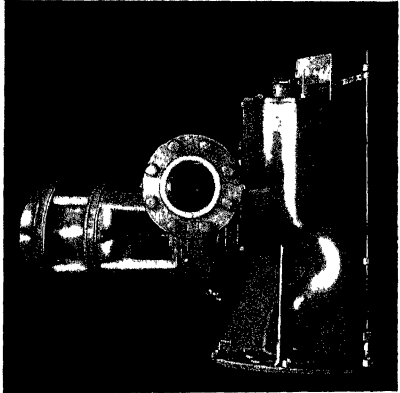
Supplied in 1, 1½, 2, 3, 4, 6, and 8 in. sizes, with capacity up to 2000 gpm. Heads up to 300 ft. Bulletin No. 322 on request.



Suction Sump and Sewage Pumps

Jennings Sump Pumps are self-priming centrifugals for handling seepage water and liquids reasonably free from solids. Sewage Pumps are equipped with non-clog type impeller for liquids containing solids. Suction piping only is submerged. Centrifugal impeller and vacuum priming rotor are mounted on same shaft that carries rotor of the driving motor, forming a single moving element, rotating without metallic contact.

Will handle air or gas with liquid being pumped, and because of self-priming feature are installed entirely outside of pit, affording perfect accessibility for inspection or cleaning. Capacities to meet all requirements. Bulletins Nos. 159, 161, and 338 on request.

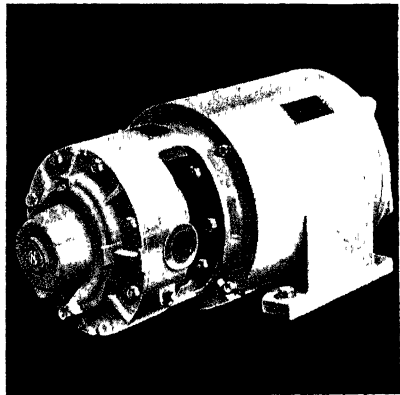


Air Compressor and Vacuum Pump

Nash Air Compressors operate on a unique and different principle. The one moving part rotates in casing without metallic contact. There is nothing to wear, and no internal lubrication.

Nash Compressors deliver absolutely clean air; ideal for agitation of liquids, pressure displacement, and handling gases. Vacuum pumps ideal for priming pumps, blood sucking pumps in hospitals, and wherever non-pulsating vacuum is required.

Pressure 75 lb or vacuum 27 in. of mercury. Furnished for any capacity; special for higher vacuums and pressures. Bulletins Nos. 282, 325, 331 and 337 on request.



ADSCO
PRODUCTS
for STEAM
SERVICE

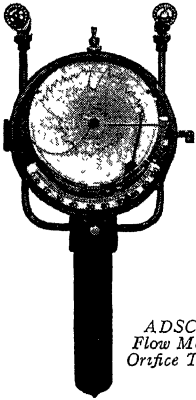
AMERICAN DISTRICT STEAM COMPANY

NORTH TONAWANDA, N.Y.

IN BUSINESS OVER SIXTY YEARS

Branches and Agents in Principal Cities

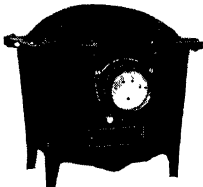
For Data on ADSCO Expansion Joints, refer to Insulation, Underground, page 1117.



ADSCO
Flow Meter
Orifice Type

ADSCO FLOW METER—ORIFICE TYPE

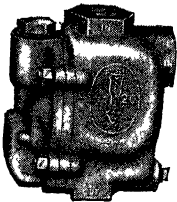
Exceptionally accurate at all rates of flow and will meter steam, water, gas or air. It is a compact unit for indicating, recording and integrating the flow and can be furnished in other combinations of these three devices. Easily installed and maintained by the purchaser. Frictionless meter mechanism, records on evenly-divided, direct-reading chart, giving a daily record from which to determine heating or processing costs. Write for Bulletin No. 35-83G.



Rotary Condensation Meter

ROTARY CONDENSATION METER

Measures steam consumption by metering condensate from heating systems or industrial equipment. Accurate within 1 per cent and factory tested to 150 per cent of rated capacity. Compact, easily cleaned, tamper-proof and equipped with non-fogging counter mechanism. Counter reads directly in pounds. Suitable for vacuum or gravity service. Available in 7 sizes from 250-12,000 lb per hour capacity. Write for Bulletin No. 35-80AG.



ADSCO Vertical Steam Trap

ADSCO VERTICAL STEAM TRAP

A float type steam trap with or without thermostatic air by-pass for vacuum service to 15 lb pressure and gravity service to 125 lb pressure. The cover with all working parts can be removed without disturbing the piping connections. The trap is equipped with a reversible valve and reversible seat of stainless alloy steel. Write for Bulletin No. 35-86G.



ADSCO Instantaneous Water Heater

ADSCO HEAT EXCHANGERS

Made in various sizes and capacities to heat or cool water, oils, other liquids or gases according to expert engineering specifications. Simple in design, sturdy in construction, dependable and economical in operation. Available in U-tube or straight tube types of heaters, economizers, condensate coolers or special units. Write for Bulletin No. 35-75BG, 35-76G.

E. B. Badger & Sons Co.

General Office: 75 Pitts Street, Boston, Mass.

Representatives

ATLANTA, GA	140 Edgwood Ave.	KANSAS CITY, MO	1332 Oak St.
BIRMINGHAM, ALA	435-7 Brown-Marx Bldg	LONDON, ENGLAND	153 Moorgate
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ENGINEERS AND MANUFACTURERS

Manufacturers of Copper and Stainless Steel Badger Corrugated Expansion Joints; Engineers and Manufacturers of Chemical Apparatus; Engineers on Process Work; Designers of Complete Plants.

More than forty years' experience in design, manufacture and application are back of BADGER EXPANSION JOINTS. Most recent developments emphasize the constant study Badger engineers are giving to expansion joint development:

1 . . . **Application of Heat Treatment** . . . scientific heat treatment is applied throughout the fabrication of Badger Expansion Joints with the result that the buyer gets all the benefits of this important metallurgical step.

2 . . . **Directed Flexing** . . . involving a new design corrugation and equalizing ring, resulting in much longer joint life. The all-curve Directed Flexing corrugation distributes flexing stresses which, with straight-sided corrugations, tend to localize.

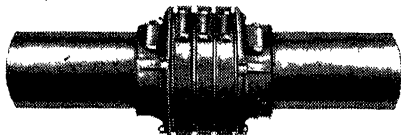
3 . . . **Stainless Steel Joints** . . . perfected after years of study and testing with this useful metal . . . now practicable to use the packless type of joint for high temperatures and high pressure conditions.

The BADGER Expansion Joint is the packless type. Requires no servicing throughout its long life. Ideal particularly for underground use or in cramped quarters. Wide range of traverse.

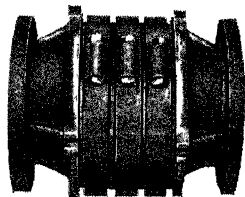
BADGER

Self-Equalizing, Directed Flexing, Expansion Joint

Designed for traverses from small fractions of an inch up to 6 inches single some joints available for double amount of traverse; for pressures ranging from high vacuum to 300 pounds (copper); special joints for higher pressures. Standard joints will withstand temperatures up to 500 F (copper); stainless steel for higher temperatures. List prices, installation and other data in **Bulletin 100**.



Welding End and Flanged End, Directed Flexing, Self-Equalizing Expansion Joints.



BADGER

Non-Equalizing Expansion Joint

Designed principally for traverses up to ½ inch and for pressures up to 25 pounds; also good as the connecting element between adjacent equipment to absorb vibrations or limited lateral displacements; standard shapes: round, oval, square or rectangular; special shapes to order. **Bulletin No. 200.**

BADGER Flexible Pipe Line Seal

Designed to be used on pipe passing through walls, foundations or bulkheads, the purpose being to allow expansion and contraction but to seal the opening against seepage of ground or other waters. **Bulletin No. 300.**



Armstrong Machine Works

851 Maple Street Three Rivers, Mich.

Representatives
in All
Principal
Cities

Armstrong offers two types of traps for heating, air conditioning, and steam distribution service.

Standard Inverted Bucket Traps, the type originated by Armstrong, are *non-airbinding* and *self-scrubbing*. They are used for low, medium, and high pressure service where relatively little air must be handled along with the condensate. Their free-floating lever design makes it possible to open very large discharge orifices compared with the size of the trap itself.

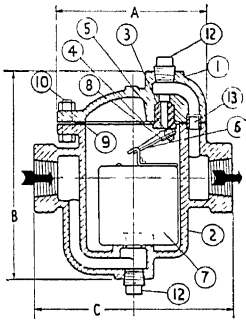
Armstrong Blast Traps are used where large amounts of air must be vented quick-

ly when steam is first turned on. They have several advantages over the conventional float and thermostatic trap.

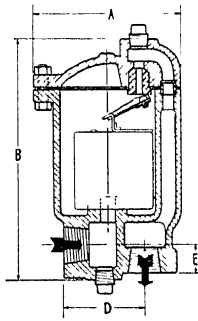
1. The Armstrong Blast Trap has but a *single orifice* to be maintained tight against the full pressure differential.

2. *Positive action*. The discharge valve in an Armstrong Blast Trap is either wide open or tight shut. Fast opening and fast closing prevent wire-drawing.

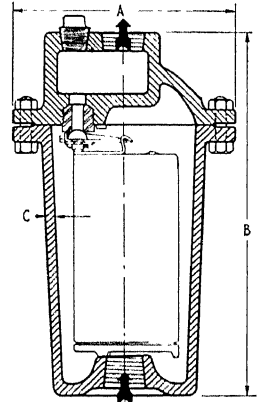
3. *Handles dirt*. There are no dead spots in an Armstrong Trap in which dirt can settle and interfere with the operation of the trap.



Cross-section of No. 800, 811, 812 and 813 traps for straight-through pipe connections.



Cross-section of No. 801 trap for standard angle pipe connections.



No. 211-216, Bottom inlet Type

Side Inlet Traps

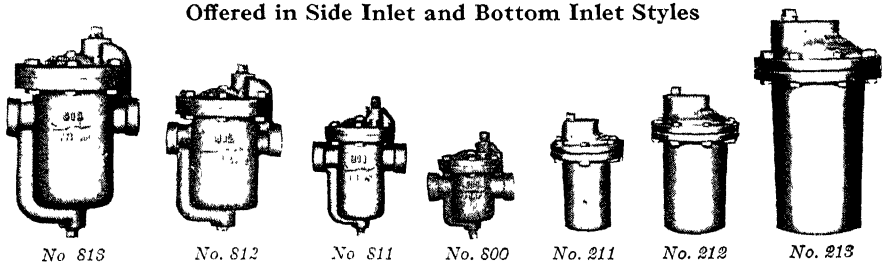
Trap Size	No. 800	No. 811	No. 812	No. 813	No. 801
Pipe Connections	1/2" or 3/4"	1/2" or 3/4"	1/2" or 3/4"	3/4" or 1"	1/2" or 3/4"
List Price (Regular)	\$7.00	\$10.00	\$16.00	\$22.00	\$7.00
List Price (Blast Trap)	\$8.50	\$11.50	\$18.00	\$24.00	\$8.50
Telegraph Code (Regular)	Aloe	Brown	Cherry	Dawn	Arrow
Telegraph Code (Blast Trap)	Aloette	Brownette	Cherette	Dawnette	Arrowette
Dimension A	3 3/4"	3 3/4"	5 5/8"	7"	3 3/4"
" B	5 1/8"	6 1/16"	8 1/16"	11 1/4"	6"
" C	5"	5"	6 1/2"	7 3/4"	
" D					2 1/16"
" E					1 1/16"
Number of Bolts	6	6	6	6	6
Diameter of Bolts	1/4"	1/4"	3/8"	1/2"	1/4"
Weight	4 1/2 lbs.	5 1/2 lbs.	13 1/2 lbs	25 lbs.	4 1/2 lbs.
Maximum Pressure, lbs.	125	250	250	250	125
Continuous discharge capacity in lb of water per hour at pressure indicated. For more complete information see the Capacity Chart in Armstrong Steam Trap Book.	5	450	830	1600	2900
	10	560	950	1900	3500
	15	640	1060	2100	3900
	20	690	880	1800	3500
	30	500	1000	2050	4000
	50	580	840	1900	4100
	70	660	950	2200	3800
	100	640	860	1800	3600
	125	680	950	2000	3900
	150		810	1500	3500
	200	*See Note at right		1200	3200
	250			760	1300
					3500



No. 801

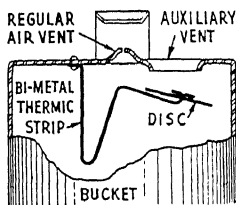
*No. 800 and 801 Traps are not regularly furnished for pressures above 125 lb to avoid small orifices that might plug up with dirt.

Offered in Side Inlet and Bottom Inlet Styles

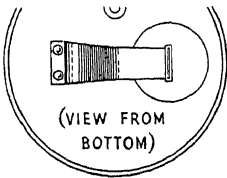


4. The wearing parts in all Armstrong Traps are identical in design, material, and precision workmanship with parts used in Armstrong Forged Steel Traps for pressures up to 1500 lb gage and total temperatures of 850 F.

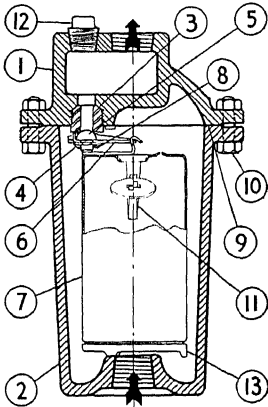
Armstrong Steam Trap Book. This 36 page book gives complete information on all sizes and types of Armstrong Traps. It also contains 17 pages of data on the subject of trap selection, installation, and maintenance. A free copy will be mailed on request.



FOR
BLAST
TRAP
JOBS



ALL Armstrong traps are readily convertible into "Blast" type traps merely by using buckets equipped with the patented auxiliary thermic air vent. As shown in the above sketches, the mechanism for this vent consists of a stainless steel disc slotted to receive the end of a bi-metal strip. Different coefficients of expansion in the bi-metal cause it to bend down when cold and up when hot. Normally, it is set to close at 212 deg, but it can be set to close at higher temperatures. Capacity, 50 to 100 times the air-venting capacity of a standard trap.



No. 211-216, Blast Type

Bottom Inlet Traps

Trap Size	No. 211	No. 212	No. 213	No. 214	No. 215	No. 216
Pipe Connections	1/2"	1/2" or 3/4"	1/2" or 3/4"	1"	1" or 1 1/4"	1 1/2" or 2"
List Price (Regular)	\$ 9.25	\$15.00	\$20.75	\$29.00	\$38.00	\$55.00
List Price (Blast Trap)	\$10.75	\$17.00	\$22.75	\$31.50	\$40.50	\$60.00
Telegraph Code (Regular)	Aspen	Birch	Walnut	Hemlock	Larch	Tamarack
Telegraph Code (Blast Trap)	Aspette	Birette	Walette	Hemlette	Larette	Tamrette
Height.....Dimension B	6 3/8"	8"	10 1/4"	12 1/2"	14"	16 3/4"
Diameter....." A	4 1/8"	5"	6 3/8"	7 1/2"	8 1/2"	10 3/4"
Wall Thickness....." C	3/8"	1/4"	3/8"	3/8"	3/8"	7/8"
Diameter of Bolts.....	1/4"	1/4"	3/8"	3/8"	1/2"	1/2"
Number of Bolts.....	6	8	6	8	8	12
Weight.....	5 1/2 lb	10 1/2 lb	19 lb	32 lb	47 lb	80 lb
Maximum Pressure, lb	250	250	250	250	250	250
Continuous discharge capacity in lb of water per hour at pressure indicated. For more complete information, see the Capacity Chart in the Armstrong Steam Trap Book.	Lb Pressure					
	5	830	1600	2900	4800	14500
	10	950	1900	3500	5800	17300
	15	1060	2100	3900	6500	19200
	20	880	1800	3500	6000	18500
	30	1000	2050	4000	6800	18000
	50	840	1900	4100	6500	18200
	70	950	2200	3800	6000	18300
	100	860	1800	3600	6200	18000
	125	950	2000	3900	6700	20000
	150	810	1500	3500	5700	18500
	200	860	1600	3200	5300	17500
	250	760	1300	3500	5700	19000

Cochrane Corporation

3130 North 17th Street, Philadelphia, Pa.

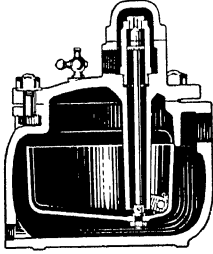
Branch Offices in 40 Principal Cities

COCHRANE HEAVY-DUTY STEAM TRAPS

A high pressure unit for condensate drainage of steam lines, separators, coils, evaporators, etc., and for conditions involving relatively high drainage rates. Recommended for pressures up to 400 lb.

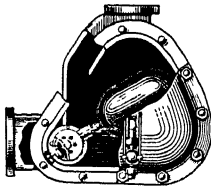
Simple construction. No levers, constricted passages or stuffing boxes to become clogged with sediment or scale. All parts are readily accessible. Action is quick and positive, avoiding wire drawing and erosion.

Write for publication No 2850.



MULTIPORT DRAINERS

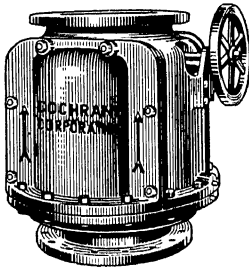
Of the multiport type, they afford unusual capacity for removing condensate or drips from purifiers, separators, jackets, radiators, pressure heating or drying coils, etc. Eliminating condensate delivers maximum heat from steam production at lower cost. Tremendous capacity assured by large port areas. Provides continuous discharge instantly responsive. Compact and light in weight. For pressures up to 150 lb.



Multiport Drainer

COCHRANE MULTIPORT RELIEF VALVES

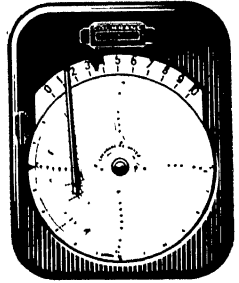
For back pressure, atmospheric relief, flow or check valve service on air, gas, steam or water lines. Positive protection against stuck, jammed or "frozen" valves as a number of small disks are used instead of one large disk. Write for publication No. 2870.



Multiport Back Pressure Valve

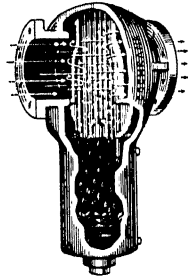
COCHRANE FLOW METERS

Flow meters of both mechanical and electrical types for measurement of steam, liquids and gases. Mechanical meter uses no working parts in the pressure chambers and no stuffing boxes. The electric meter measures flow by the extremely accurate galvanometer null principle. The new "Linameter" measures corrosive or viscous fluids. Publication 3010.



ALL-SERVICE SEPARATORS

Cochrane Separators purify steam by separating out oil, slugs of water and condensate. Complete removal of entrainment is accomplished by vertical baffle ribs which guide it into a direct unrestricted fall, and a baffle area which extends far beyond the flow from the inlet pipe. Ports at the sides of the baffle prevent the purified steam from passing over the drip area and coming into contact with the entrainment. The steam flow is uninterrupted and pressure loss is minimized.



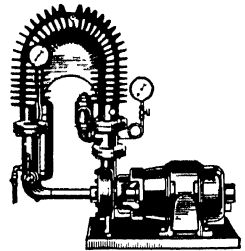
All-Service Separator

COCHRANE-BECKER HIGH PRESSURE CONDENSATE RETURN SYSTEM

In unit heaters, coil radiation, blast heaters, etc., this system will reduce fuel costs by returning condensate direct to boilers at high temperatures and pressures. Advantages are:

1. Faster Heating.
2. Higher Temperatures.
3. More Uniform Heating.
4. Lower Maintenance.

Plus 5 to 28 per cent fuel saving. Write for Publication 3025.



GRINNELL COMPANY^{INC}

Heating, Industrial and Power Plant Piping, Fittings, Hangers, Valves, Pipe Bending, Welding, Piping Supplies, Etc.

Executive Offices: **Providence, R. I.**

National Distributors of Thermoflex Traps and Heating Specialties

For data on other Grinnell Products, see pages 1026-1027

Thermoflex Specialties

The heart of all Thermoflex Traps is the Hydron Bellows.

The Hydron Bellows is formed under hydraulic pressure. This powerful internal pressure locates any weakness of any nature in the tubing. Such hydraulic pressure is many times more severe than any pressure the Trap will ever be called upon to control. Every Thermoflex Trap, therefore, is practically indestructible.

Thermoflex Traps have an exceptionally large orifice. This large orifice combined with high lift, insures fast action and freedom from clogging.

We supply Thermoflex Traps guaranteed for steam pressures of 25 lb. to 50 lb and to 125 lb. Complete information and details of typical installations will be gladly sent on your request. Ask for Catalogue on Thermoflex Heating Specialties.

Thermoflex Low Pressure Line

The entire Thermoflex line of low pressure specialties, designed for maximum steam pressure of 25 lbs, has been simplified to meet wartime needs with respect to critical materials. This simplification has been accomplished without sacrifice of quality or performance—only the appearance has been altered by the change from bronze to cast iron for the structural parts.

The new low pressure victory line includes thermostatic traps in angle pattern only, with cast iron bodies without unions, in the following sizes:

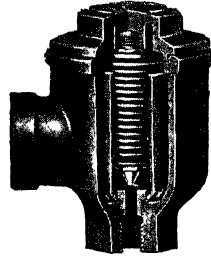
- 1½ inch—200 sq ft rad. capacity.
- ¾ inch—400 sq ft rad. capacity.
- ¾ inch—700 sq ft rad. capacity.

A complete range of sizes of Combination Float and Thermostatic type traps continues to be available, as well as the Thermoflex Vapor Specialties for small and medium size installations.

Thermoflex Medium Pressure Traps

Thermostatic type traps, and Combination Float and Thermostatic type traps are furnished for working steam pressures in the range from 25 to 50 lbs.

Thermoflex High Pressure Traps



The No. 100A Thermoflex Trap is guaranteed for steam pressures from 50-125 lb. Must not be used where the steam temperature exceeds 400 F.

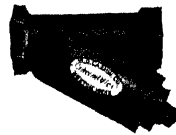
For use with all types of process work, Laundry Machinery, Kitchen Equipment, Hospital Sterilizers, Vulcanizers, Dry Kilns, Unit Heaters, Street Steam Service, etc., in fact any place that a trap is desired for service at the above pressures.

Small, compact and inexpensive.

Extra heavy body. Renewable nickel steel seat and disc. Bellows made from special bronze tubing and encased in brass sleeve to prevent distortion due to pressure.

Regularly furnished without unions.

Thermoflex Streamlined Strainers



Pipe line strainers of the self-cleaning Y-type are furnished for pressures up to 250 lbs, and in sizes ¾ in. to 2 in. These are heavy duty strainers with semi-steel body and brass screen, which are suited to a wide field of use in removing harmful substances from pipe lines carrying steam air and fluids.

Kieley & Mueller, Inc.

Since 1879

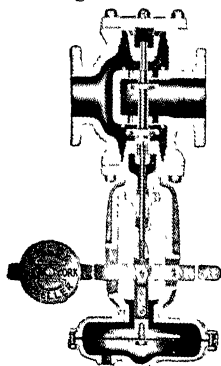
PRESSURE AND FLOW CONTROL VALVES AND EQUIPMENT

General Offices and Factory: 2013-2033 43rd Street, North Bergen, N.J.

Representatives in All Principal Cities

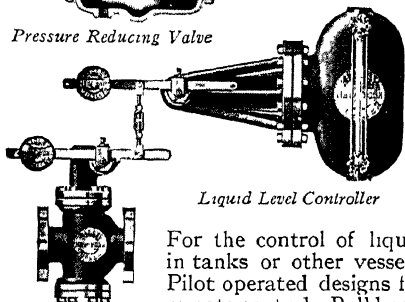
Producing in America's most modern specialty factory, all types of Pressure Reducing Valves, Liquid Level Controls, Steam Traps, Basket and Y Type Strainers, Pump Governors, Back Pressure Valves, Exhaust Heads, Steam and Oil Separators, Damper Regulators, etc.

Your problems and applications are welcomed in our Engineering Department. Catalogs and data on request.



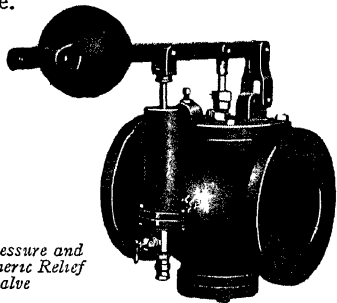
Spring and Lever Weighted Valves for all services and initial pressures up to 600 lb. Single and double seated design for steam, water, air, oil, gas. Pilot Type, Remote Control Type.

Pressure Reducing Valve



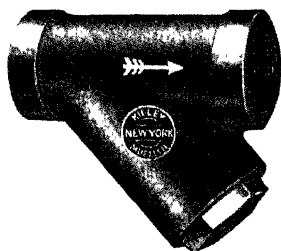
Liquid Level Controller

For the control of liquid in tanks or other vessels. Pilot operated designs for remote control. Ball bearing Spindle, Pack Easy Stuffing Box. Twenty other types of Level Controls available.



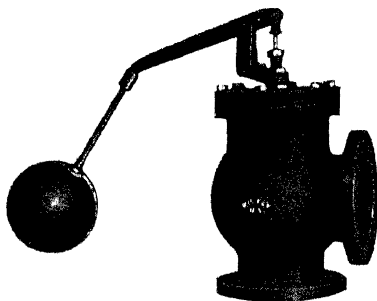
Back Pressure and Atmospheric Relief Valve

For either condensing or non-condensing Engines or other back pressure types of controls. Noiseless in operation. Maintains back pressure from 0 to 25 lb. Horizontal and Vertical lever and weight or spring operated design.



"Y" Type Strainer

"Y" Type Strainers from $\frac{1}{4}$ in. to 6 in. Pressures up to 600 lb. Bronze, Cast Iron and Steel. Also Basket Strainers $\frac{1}{2}$ in. to 16 in. Bolted and Clamped Cover designs.



Float Valve

Float Valves in all sizes from $\frac{1}{2}$ in. to 12 in. in Globe and Angle Design. Pilot Operated and Direct Operated. Special design for cold water.

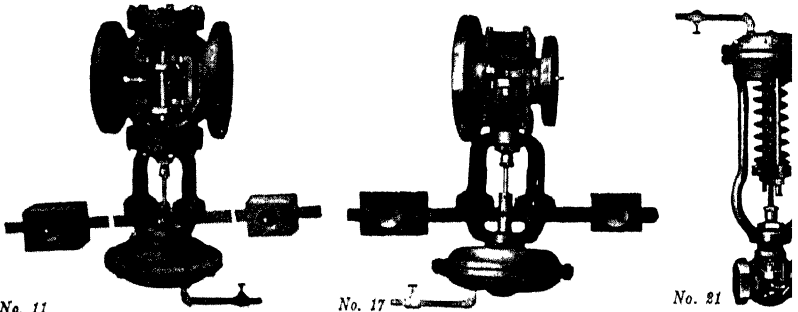
For the duration of the War, Kieley & Mueller must naturally concentrate on fulfilling the Government requirements, particularly for shipboard regulators, strainers, etc. Deliveries are therefore subordinated depending on priority. Our customers will be given our continued best cooperation on their requirements so far as it is possible.

Mueller Steam Specialty Co., Inc.

40-20 22nd Street, Long Island City, N. Y.

Steam, Water, Air, Oil and Gas Specialties for Heating and Power Plants

Pressure Reducing Valves—Straight Pattern and With Increased Outle



No. 11

No. 17

No. 21

No. 11—For Vacuum, Vapor and Low Pressure Heating Systems. Initial Pressure up to 200 lb; Reduced Pressures, 0 to 10 lb.

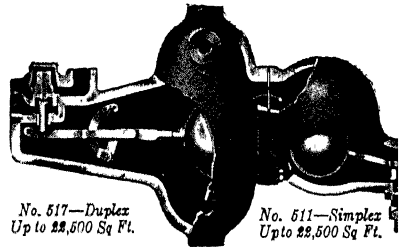
No. 17 and 21—For automatic control of reduced pressures on dead-end service requiring a tight closing valve, such as tank heaters, kitchen utensils, sterilizing apparatus, laundry equipment, kettles, cookers, driers, etc. Initial Pressures up to 200 lb; Reduced Pressures 0 to 150 lb.

Constructed with full globe bodies. Center guide eliminates the wings on discs, increases efficiency, assures minimum noise and prolongs the life of the seats and discs. Lever and weight operates on a steel roller bolt, assuring a most sensitive valve. Spring type furnished with special long springs for sensitive operation and wide range of reduced pressures.

Automatic Water Feeders

With a powerful leverage to control the water line in steam boilers, etc. They supply make-up water to compensate for evaporation, leaks, steam utilized in process work and condensation wasted. Where condensation held up in the system eventually returns in large quantities, our Duplex type protects the boiler against flooding. All working parts of non-corrosive metal, are accessible without breaking pipe connections. Provided with an integral strainer. For steam pressures up to 100 lb, water pressures up to 120 lb.

Equipped with single and double contact mercury Tube Switches for all services.



No. 517—Duplex
Up to 22,500 Sq Ft.

No. 511—Simplex
Up to 22,500 Sq Ft.

Steam Traps

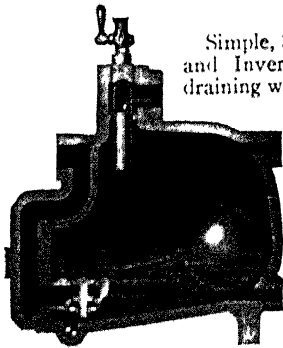
Simple, Sturdy and Compact Ball Float and Inverted Bucket Steam Traps for draining water of condensation from steam apparatus and steam mains.

Powerful leverage enables them to take care of large quantities of condensation.

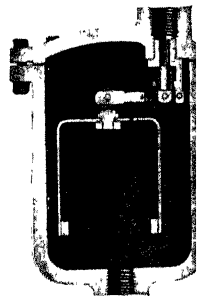
Ball Float Steam Traps equipped with integral strainer, water gages, air cocks, blow-off and integral by-pass valve, when desired.

All working parts are accessible without disturbing any pipes.

Valves are sealed with several inches of water, making the escape of steam impossible.



Ball Float
No. 219—Up to 30 lb
No. 221—Up to 150 lb
Size 1/2 to 3 in.



Inverted Bucket
No. 211—For Pressure
Up to 200 lb.
Size 1/2 to 3 in.

CATALOGUE and BULLETINS covering our COMPLETE LINE gladly furnished on application.

Wright-Austin Co.

309 West Woodbridge St., Detroit, Mich.

PRODUCTS—Steam Traps, Strainers, Air Traps, Steam and Oil Separators, Compressed Air Purifiers, Exhaust Heads, Boiler Feeders and Controllers, Alarm Water Columns, Water Gauges, Trycocks.

"Airxpel" Bucket Type Steam Traps

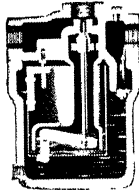
Are "double duty" traps, because they automatically discharge both air and condensate.

Union connections make them easy to connect up. Also, furnished with screw connections when desired. They save money for fittings and installation labor, by having straight through horizontal pipe connections.



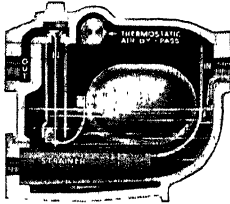
The Cub sizes are made in $\frac{1}{2}$ in., $\frac{3}{4}$ in., 1 in. Especially suitable for individual unit drainage on heating and process equipment.

Also three "Master" sizes $\frac{1}{2}$ in. to 2 in., for general service.

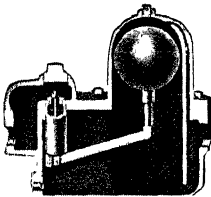


"Combination" Steam Traps

Float Type with internal thermostatic air bypass and strainer for pressures 0 to 40 lb. A modernly designed and very successful trap for vacuum and pressure heating.



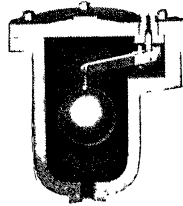
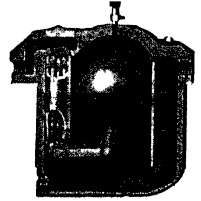
"Victor" Low Pressure Steam Traps



A heavy duty trap for large volumes of condensation at low pressures.

"Emergency" Float Type Steam Trap

Three valve trap with large capacity at high pressures. An exceptionally reliable trap for use in inaccessible places.



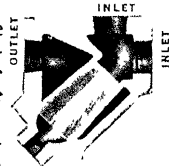
Air Relief Traps

For relieving air from forced circulation hot water heating systems, water supply lines, closed tanks, receivers, pumps, etc.

"Tuway" Strainer

May be used two ways - as a straight-way or angle strainer, in either horizontal or vertical pipe line, because it has the choice of two inlets at right angles to one another.

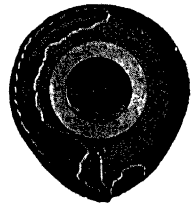
For cleaning, flush through blow-off connection, or remove screen by unscrewing bottom plug.



Separators—Steam and Oil

Type "A" Vertical Steam

Type "S" Horizontal Oil



We make separators of every type and all sizes for all pressures.

Exhaust Heads

Designed to eliminate noise and spray. Three types to select from—the "Cyclone" Heavy Duty, and Standard Galvanized Steel—also, the cast iron type, to remedy all conditions. Sizes 1 in. to 48 in.



Send for descriptive Bulletins on any of the items listed on this page.

Yarnall-Waring Company

Manufacturers of



Steam Specialties

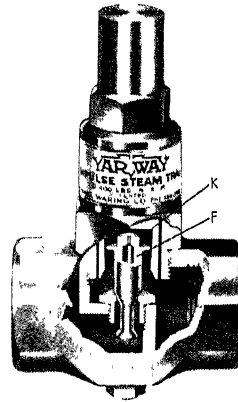
7600 Queen Street, Philadelphia, Pa.

YARWAY IMPULSE STEAM TRAPS

Construction The Yarway Impulse Steam Trap is unique in that there is only one moving part, the simple valve F. This trap is made of bar stock throughout, no castings used. Body and bonnet of cold rolled steel, cadmium plated; cap of tobin bronze, valve and seat of heat treated stainless steel. For pressures 400 to 600 lb, bonnet and cap are stainless steel.

Operation Movement of valve (F) is governed by changes in pressure in control chamber (K). When handling ordinary condensate, tiny control flow bypassing continuously through orifice in center of valve reduces chamber pressure below inlet pressure and valve opens, allowing free discharge through seat. As condensate approaches steam temperature, low chamber pressure causes vaporizing of control flow. The increased volume builds up pressure in control chamber, closing valve (F).

Factory set to operate at all pressures up to 400 lb (or 600 lb) without change of valve seat.



Advantages

Light Weight Yarway traps need no support $\frac{1}{2}$ in. trap weighs only $1\frac{3}{8}$ lb. 2 in. trap weighs $8\frac{5}{8}$ lb.

Small Size They practically eliminate radiation losses can be installed in cramped quarters $\frac{1}{2}$ in. trap measures $2\frac{1}{4}$ in. long 2 in. trap, $4\frac{3}{4}$ in. long.

Will not air bind.

Require no priming.

Insure quick heating.

Operate on exclusive Impulse principle (U. S. Patents No. 2,051,732 and 2,127,649.)

Low Price Often cheaper than repairing old traps.

List Prices, Weights and Dimensions

No. 60 Series—up to 400 lbs. and

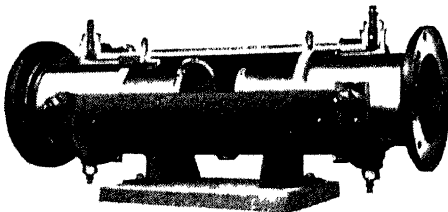
No. 70 Series—up to 600 lbs.

Size	Trap Complete	Weight Pounds	Length Inches
$\frac{1}{2}$ " Nos. 60 or 70	\$15.00	$1\frac{1}{4}$	$2\frac{5}{8}$
$\frac{3}{4}$ " Nos. 61 or 71	22.00	2	3
1" Nos. 63 or 73	31.00	$2\frac{1}{2}$	$3\frac{3}{8}$
$1\frac{1}{4}$ " Nos. 64 or 74	48.00	4	$3\frac{3}{4}$
$1\frac{1}{2}$ " Nos. 66 or 76	68.00	$5\frac{3}{4}$	$4\frac{1}{4}$
2" Nos. 67 or 77	90.00	$8\frac{1}{2}$	$4\frac{3}{4}$

For further information send for descriptive bulletin T-1737.

YARWAY GUN-PAKT EXPANSION JOINTS

All-steel welded construction; light but strong. Chromium covered sliding sleeves.



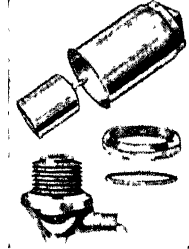
Cylinder guide and stuffing box integral, assuring perfect alignment. Internal limit stops. Gun-pakt and Gland-pakt types; Gun-pakt (illustrated) fitted with screw guns which permit insertion of plastic packing while joint is under pressure. Sizes 2 in. to 24 in., single end or double end, flanged or welding ends; 150, 300 and 400 lb pressures. For additional details send for bulletin EJ-1908.

Anderson Products, Incorporated Cambridge, Massachusetts

Vent-Rite Controlled-Venting Radiator Valves . . . Vent-Rite No. 66 Control Valves . . . Vent-Rite Balancer . . . Vent-Rite Unit Heater Valve. Originators of "Balanced Radiation by Controlled Venting," "The Vent-Vac Method" and "Vacuum Limitation."

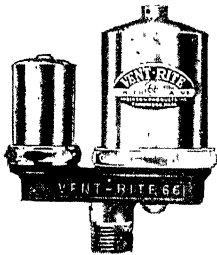
These Valves are **REPAIRABLE**

Most important under present conditions is the fact that all Vent-Rite Valves are repairable. They may be taken apart, cleaned, and reassembled, and in addition they may be submitted to the factory for the replacement of damaged parts. This result of Anderson foresight has been a real contribution to the extension of heating facilities under material shortages.



THE VENT-VAC METHOD

The Vent-Vac Method provides more even room temperatures. This is accomplished by continuing the distribution of steam between firing periods. The steam is available through the use of heat left in the boiler, and it is distributed to the points of greatest heat loss. To insure fast, uniform distribution of steam during the firing periods, it breaks the vacuum used between firing periods for this purpose. This "breaking" of the vacuum occurs as soon as firing starts, restoring the system to atmospheric pressure. Vent-Rite Vacuum Valves, and a Vent-Rite Control Unit are used. The system is simple, economical, and amazingly effective. Vent-Rite Control Units not only create vacuum in the system between firing periods, but also limit the amount of vacuum that can be created to the point beyond which the distribution of excessively expanded vapor would be inefficient. This is another feature developed and pioneered by Vent-Rite and offered only in Vent-Rite Units.



No. 66

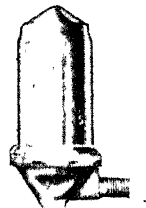
VENT-RITE CONTROL VALVES

Vent-Rite Control Valve No. 66 is the heart of the Vent-Vac Method of steam control for automatically-fired, one-pipe systems. It takes the place of a main line vent, limits the amount of vacuum created and breaks the vacuum at the beginning of the firing period. It is entirely mechanical. With the Vent-Vac Method, using a No. 66 Control Valve, a system is "Vacuum" between Firing periods, "Non-Vacuum" during Firing, combining the best of both systems assuring "Balanced Radiation."

VENT-RITE RADIATOR VALVES

Vent-Rite Controlled-Venting Radiator Valves are made in a wide variety of types, sizes, outlets, and venting capacities. Both Vacuum and Non-Vacuum. All are noiseless in operation, positive in action, close thermostatically under temperature. They may be taken apart for examination and cleaning. Venting is through an adequate straight-line venting orifice, accurately set by a newly designed inconspicuous steam-lined Adjusting Disc. For 1942 Vent-Rite also offers a new Siphon Tongue for use especially with small-tube radiation.

The Vent-Rite Line includes Nos. 1, 51, 3, 5A and 55 (Non-Vacuum); 2, 62, 4, 6A, 66, 68 and the Balancer (Vacuum).



No. 2

The Dole Valve Company

Main Offices and Factory: 1901-1941 Carroll Avenue, Chicago, Ill.

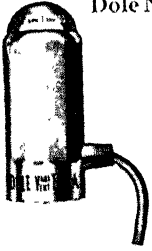
THE ALL STAR LINE

Dole

AIR AND VACUUM VALVES

Selecting the right vent for a particular purpose is your assurance of the utmost efficiency and economy from one pipe steam heating systems. The Dole line covers every venting need and offers a complete choice for every purpose.

Dole No. 1A Vari-Vent Air Valve



Modern gas, oil or stoker fired one pipe steam systems require QUICK venting. This radiator valve lets air escape twice as fast as ordinary valves and balances the flow of steam at the first "breath" of boiler pressure. Adjustable vari-vent feature gets air out of those "far away"

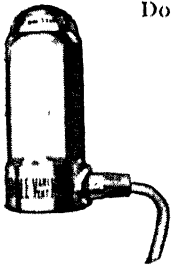
radiators as quickly as those close to the boiler.

Dole No. 3 Air Valve



Vents radiators of hand fired gravity steam heating systems. Double shell construction provides separate passages for air and condensation - extra large float defeats spitting or water leakage. Complete venting assured at pressures up to 10 lbs.

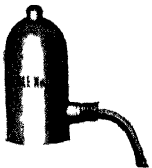
Dole No. 2B Vari-Vent Vacuum Valve



Adjustable radiator valve for "vacuumizing" and balancing gravity steam heating systems. Patented Dole bellows vacuum seal locks out air after it has been once expelled from the system. Easily adjusted vari-vent feature assists

in equalizing steam flow to all radiators.

Dole No. 1933 Air Valve



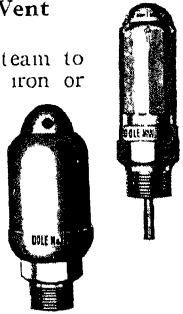
Low cost valve for venting radiators of hand fired systems. Large float provides a seal against condensation to stop spitting.

Dole No. 1B Vari-Vent Air Valve

Balances the flow of steam to convectors, either cast iron or copper, of automatically fired systems.

Dole No. 1C Quick Vent Float Valve

Vents mains and speeds flow of steam to radiators of automatically fired systems. Extra large venting port.



Dole No. 5 Quick Vent Float Valve

Vents steam mains on hand fired systems. Positive seal against water.

Dole No. 4 Quick Vent Valve

For quick venting mains that end 18 in. or more above the boiler water line.

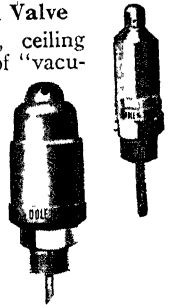


Dole No. 103 Vacuum Valve

For venting convectors, ceiling radiators and pipe coils of "vacuumized" gravity steam systems.

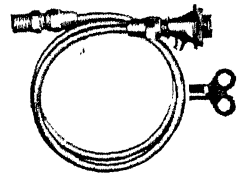
Dole No. 6B Vacuum Valve

Vents the mains of "vacuumized" one pipe steam systems. Prevents the return of air. Closes against water.



Dole No. 14 Key Valve

Low cost venting device for concealed radiators and convectors of hot water heating systems. Protects panel fronts from rusty water stain.



Write The Dole Valve Company for complete catalog and handy selector chart which indicates the Dole Air or Vacuum Valve most suited for a particular need.

Jenkins Bros.

BRONZE - IRON - STEEL VALVES

Mechanical Rubber Goods

80 WHITE ST., NEW YORK, N. Y.; 524 ATLANTIC ST., BOSTON, MASS.; 376 SPRING ST., N. W., ATLANTA, GA.;
133 N SEVENTH ST., PHILADELPHIA, PA.; 1514 FULTON ST., CHICAGO, ILL.;

BRIDGEPORT, CONN. (Office and Factory)

JENKINS BROS., LTD • MONTREAL; Factory, LACHINE, CANADA • LONDON, ENG.

IN VALVES



Jenkins

GIVES YOU EVERYTHING



Fig. 762
Bronze Regrinding
Swing Check

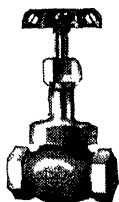


Fig. 106A
Bronze Globe,
Renewable Comp. Disc

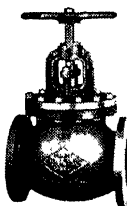


Fig. 613
Iron Body
Regrinding Globe



Fig. 370
Bronze Gate

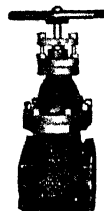


Fig. 325
Iron Body Gate



Fig. 624
Iron Body Regrinding
Swing Check

**OVER 500 DIFFERENT JENKINS VALVES
COVER EVERY HEATING AND AIR CONDITIONING NEED**

To adequately describe the complete Jenkins line of valves requires a Catalog of more than 400 pages. There are over 500 different types and patterns of valves that bear the trusted "Diamond" trade mark. Practically speaking, Jenkins can furnish any valve that you may require for plumbing, heating, air conditioning, general industrial or engineering service.

General Classifications of Jenkins Valves Include—Bronze Valves fitted with Jenkins renewable composition disc. Bronze Regrind-Renew Valves with bevel and plug type seats. Bronze Gate Valves. Iron Body Valves fitted with Jenkins renewable composition disc. Iron Body Regrinding Valves. Iron Body Gate Valves with solid wedge and double disc parallel seats. All-Iron Valves. Cast Steel Gate, Globe and Swing Check

Valves. Electrically and Hydraulically Operated Valves. Radiator Valves. Fire Line Valves. Quick-opening and Self-closing Valves, Needle Valves, Y Valves, Solder-End Valves, Stainless Steel Valves.

Other Jenkins Products Are—Colored Valve Wheels with or without service markings molded in relief letters. Composition Valve Discs exactly suited to service conditions. Sheet Packing. Gaskets.

JENKINS VALVES ARE SOLD BY GOOD SUPPLY HOUSES EVERYWHERE

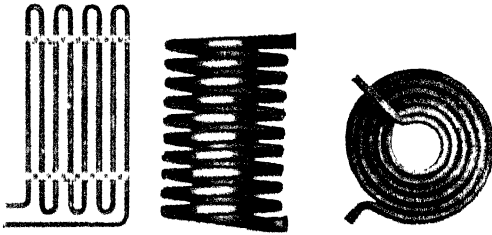
Arthur Harris & Co.

210-218 N. Aberdeen Street

Chicago, Ill.

ENGINEERS — FABRICATORS OF NON-FERROUS METALS AND STAINLESS STEEL

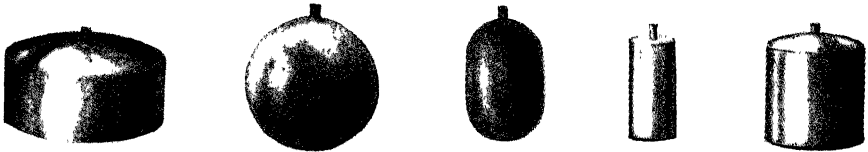
Metals Fabricated—Aluminum, Block Tin, Brass, Bronze, Copper, Everdur, Monel, Nickel, Inconel, Stainless Steel and KA2 SMO. Bulletin on request.



Coils

For heating, cooling and condensing. All shapes made from any size pipe or tube—standard or special connections, of copper, brass, aluminum, stainless steel, KA2 SMO, monel, inconel, nickel, block tin, and Everdur.

Metal Floats



Flat Cylindrical

Ball

Column

Cylindrical

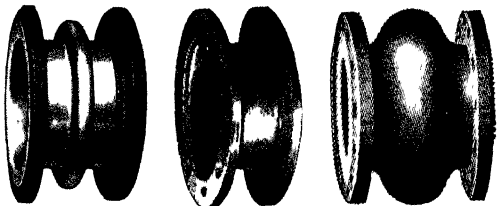
Cylindrical

Made of copper, plain steel, stainless steel, KA2 SMO, aluminum, brass, Monel, pure nickel, Admiralty and Everdur, for open tank and all pressures.

Seamless copper ball floats carried in stock in diameters of 3 in., 4 in., 5 in., 6 in., 7 in., 8 in., 10 in., 12 in. for open tank and pressures of 25, 50, 100 and 150 lb. Floats in special sizes and pressures made to order. Stainless steel ball floats 2½ in. to 12 in. for high pressure and corrosion carried in stock—special stainless steel floats made to order—stainless steel ball floats larger than 12 in. diameter can be made up specially. Float catalog sent on request.

Copper Expansion Joints

For low pressure and vacuum. Made in two styles—convex and concave. Sizes 4 in. to 60 in. diameter. Cast iron or steel flanges. Flanges drilled to American standard unless otherwise ordered: B-290 available only in sizes 4 in. to 15 in. inclusive.



B-290 Convex

B-281 Concave

B-280 Convex



Bends

We make bends in every shape from all sizes of copper water tube, pipe and tubing in copper, brass, aluminum, stainless steel, monel, tin and nickel. Standard or special connections. U-bends for storage water heaters.

Also special pipe work for industrial installations, plumbing, heating and brewing. Perforated pipe, double pipe coolers, etc.

Non-Ferrous Castings—"Dairywhite" nickel silver for Process Industries Equipment. Suitable for milk and food products machinery. Castings also of 88-10-2, 80-10-10, 85-5-5-5 and special mixtures. Many patterns available without charge.

The American Brass Company

General Offices: Waterbury, Conn.

Offices and Agencies in Principal Cities



CANADIAN ASSOCIATE: ANACONDA AMERICAN BRASS LIMITED, New Toronto, Ontario

PRODUCTS—Anaconda Deoxidized Copper Tubes and Fittings; Anaconda “85” Red-Brass Pipe; Everdur Metal for storage heaters, storage tanks, ducts and air conditioning equipment

ANACONDA COPPER TUBES AND FITTINGS

For Heating, Plumbing and Air Conditioning

Anaconda Deoxidized Copper Water Tubes assembled with Anaconda Fittings offer an unusual combination of advantages in hot water heating systems at a cost only slightly higher than black iron and approximately the same as wrought iron pipe. These advantages may briefly be summarized as follows:

Low Friction Loss—Because the inside surfaces of copper tubes are inherently smoother than those of pipe and tubes made of ferrous materials and also because they do not become roughened by the formation of rust, these tubes offer a lower resistance to flow. In addition, the long radius turns of Anaconda Elbows and the smooth inside surface of Anaconda Wrought Copper Fittings further reduce friction losses.

These factors naturally increase the efficiency of the system, particularly when it includes a forced pressure circulator.

Ease of Installation—In many places the flexibility of copper tubes simplifies connections that ordinarily would be awkward and expensive to make with rigid pipe and threaded fittings. Anaconda Solder Fittings are compact. They can be installed in constricted space where the use of a wrench would be impossible.

Architects and builders naturally object to large holes and notches cut in the

framing members of a building for the passage of piping. Anaconda Copper Tubes can be installed with a minimum of cutting in the structure—although holes should be large enough to permit movement of tubes due to expansion and contraction.

Appearance—Anaconda Deoxidized Copper Water Tubes assembled with Anaconda Solder Fittings present an attractive appearance. It is a frequent practice to clean the tubes after they are installed and apply a coat of clear lacquer or similar substance. This keeps the tubes bright and makes an installation of which both plumber and owner can be proud.

Temper and Gauges—Anaconda Copper Tubes are made in both hard and soft temper and in standard wall thicknesses.

They meet the requirements for these types of tubes in U. S. Government Specification WW-T-799 and A.S.T.M. Specification B-88-41. Type K, the heaviest, is recommended for heating lines and general piping.

Accuracy of Dimensions—Anaconda Deoxidized Copper Water Tubes are all finished to the close tolerances required by the A.S.T.M. and Federal Specifications, which have been found essential for efficient assembly with solder fittings.

Permanent Identification—For permanent identification, the name “Anaconda” and the letter designating the type of tube is stamped in the metal at intervals of approximately 18 in., throughout every coil or straight length of tube

The American Brass Company

Anaconda Copper Tubes, in all standard sizes, up to and including 1 $\frac{1}{4}$ in. are furnished soft in 30, 45 and 60-ft coils; also hard and soft in 20-ft straight lengths. Sizes over 1 $\frac{1}{4}$ in. are furnished, hard or soft, in straight lengths only.

ANACONDA "85" RED BRASS PIPE

Anaconda "85" Red Brass Pipe, in standard pipe sizes, is considered the highest quality corrosion-resistant pipe commercially obtainable at a moderate price and is recommended for steam return lines.

Anaconda "85" Red Brass Pipe contains 85 per cent copper and conforms to government specifications for Grade "A" water pipe. The words "Anaconda 85" are stamped in the metal at one-foot intervals throughout each length.

EVERDUR*

Everdur Metal is the original copper-silicon alloy. It is manufactured by The American Brass Company in four standard compositions and in practically all commercial forms.

This high strength engineering metal is immune to a wide range of corroding agents. Because of a versatile combination of useful properties, Everdur has become standard as a material for equipment in many fields of engineering and industry.

In addition to their non-rusting properties and high strength, Everdur alloys possess many qualities not usually found in metals of this character. They are unusually resistant to general atmospheric conditions and other normally corrosive factors. Everdur alloys have excellent machining and working characteristics and can be fabricated into a variety of forms and shapes. They also weld readily by any of the commercial methods.

CORROSION RESISTANCE

The corrosion resistance of Everdur is equal to that of pure copper and in some cases, slightly superior.

*"Everdur" is a trademark of The American Brass Company registered at the U. S. Patent Office.

However, like copper and all copper alloys, Everdur is not equally resistant to all corroding agents, nor to the same corroding agents under all conditions. As with copper, the resistance to corrosion may be substantially reduced in some instances by the presence of oxidizing agents. Nevertheless, Everdur does offer excellent resistance to the corrosive action of many solutions and atmospheres.

Everdur Tanks—Everdur copper-silicon alloy is an ideal material for durable, rustless water tanks of every description—from domestic range boilers to large storage heaters for hotels, laundries, hospitals, textile plants, schools or breweries.

Everdur is made in all commercial shapes including tank plates which have physical properties as given in A.S.T.M. Specification B96-42.

Minimum specification requirements for hot rolled and annealed tank plates are: Tensile Strength, 50,000 psi.; Yield Strength (at 0.5 per cent elongation under load) 18,000 psi.; Elongation, 40 per cent in 2 inches.

Sound, double welded butt joints made on annealed Everdur tank plates have a minimum tensile strength of 47,500 psi. and single welded butt joints have a minimum tensile strength of 42,500 psi. after the beads have been removed.

For additional data and names of fabricators address our nearest office or agency.

EVERDUR FOR AIR CONDITIONING EQUIPMENT

Because of its strength and welding properties, Everdur may be substituted for steel and fabricated by substantially the same methods and with the same equipment as steel.

Everdur metal has been used with marked success for fans and blowers, ducts, humidifiers, cast and wrought parts of other equipment items subject to corrosive influences.

EVERDUR LITERATURE

Descriptive literature containing much pertinent tabular data will be sent upon request.



Wolverine Tube Division

Calumet & Hecla Consolidated Copper Company
1435 Central Avenue, Detroit, Michigan

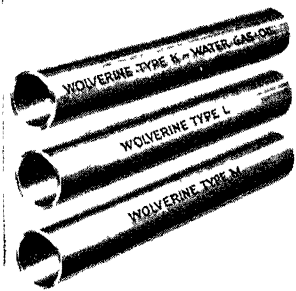
SEAMLESS TUBE COPPER - BRASS - ALUMINUM

Sales Offices:

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BALTIMORE, MD. 121 S. Gay St.
WELLESLEY HILLS, MASS. 37 Fiske Rd.
BUFFALO, N. Y. 416 Jackson Bldg
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MILWAUKEE, WIS. 617 W. Virginia St.
MINNEAPOLIS, MINN. 100 N. Second St

NEWARK, N. J. 601-608 Market St.
NEW YORK, N. Y. 120 Lexington Ave.
NEW YORK, N. Y. (Export) 100 Varick St.
PHILADELPHIA, PA. 954 Broad St. Station Bldg.
PITTSBURGH, PA. 1214 Liverpool St.
PORTLAND, ORE. 116 N.W. 14th Ave.
RICHMOND, VA. Mutual Bldg.
ST. LOUIS, MO. 1565 McRee Ave.
SAN FRANCISCO, CALIF. 7 Front St.
WASHINGTON, D. C. 808 Investment Bldg.

COPPER WATER TUBE



TYPE K—Recommended for Air Conditioning, Refrigeration, Oil Burner, and Plumbing and Heating installations.

TYPE L—For Oil Burner, Air Conditioning, Refrigeration and general plumbing uses.

TYPE M—Suitable for Air Conditioning and Refrigeration installations and for interior plumbing and heating purposes.

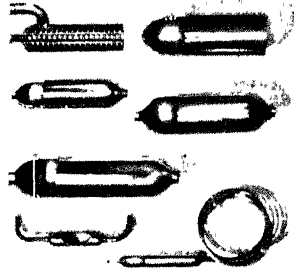
Types K and L furnished in hard or soft temper; Type M, hard only.

Wolverine Water Tube is made according to U. S. Government and A.S.T.M. specifications. For a complete list of these data, write Detroit for Form 575

REFRIGERATION TUBE

Wolverine refrigeration tube has long been the standard of the industry. Dehydrated, sealed, paper-wrapped; uniform soft temper and moisture content well below minimum specified by A.S.R.E. Available from stock in standard coils.

ACCUMULATOR SHELLS

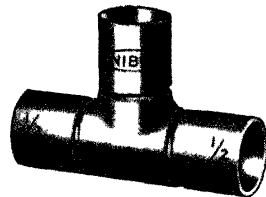


A new accumulator shell developed by Wolverine and produced to customers' specifications in a variety of shapes and sizes up to 3½ in. diameter.

It combines many advantages including one-piece construction and is especially adaptable to refrigeration problems. Send your blueprints or inquiries to Detroit.

WROUGHT FITTINGS

Wolverine-Nibco Solder Fittings are of the straight-line design ends not expanded. They make strong, neat joints; give trouble-free service, and longer life. A complete range of sizes is available. Write to Detroit or your nearest warehouse for Catalog D.



The experience of 27 years of seamless tube manufacture, the use of the latest equipment, and adherence to Government and customer specifications, are responsible for the uniform, high quality of Wolverine products. And now, backed by the 76-year experience and large resources of Calumet & Hecla, Wolverine quality is controlled from ore to finished product.

INSULATION

Many different materials are used for insulating purposes—in their natural state or processed and fabricated into various forms. They include: Vegetable fibers, wood, tree bark, cork—processed into wools or other fibrous forms, and used in loose bulk or fabricated into boards, paper, blankets or batts. Natural wools, jute, hair—felted into blankets, pads, mats, etc., or used in loose bulk forms. Glass in block, sheet, or wool forms.

Mineral products such as natural rocks and furnace slags—processed into granulated form, or into wool form and used in loose bulk or fabricated into blankets, batts, or pads; and asbestos, asphalt, gypsum and magnesia—used in board form, blankets, felts, or in loose bulk. Many of these types of insulation are also used in plastic form. Metallic insulation, such as aluminum and steel are fabricated into sheet form and used separately or in conjunction with other insulating materials.

INSULATION, Building (p. 1094-1115)

Aluminum sheets, paper in sheets and fabricated forms, felts, cork, glass, glass and rock wools, cane fibre boards, wood products in board form and fibrous blankets and pads, or used in loose fibre form—all are utilized as insulation against heat or cold.

Technical data on this type of insulation will be found in Chapter 4.

Insulating materials, in board or slab form are adapted for use in walls as a plastic base, and thus serve as both a heat or cold insulation and a fire-retarding material.

INSULATION, Sound Deadening (p. 1094-1119)

Many of the insulating materials utilized in building construction are also suitable for sound deadening or acoustical control. Some of them are also adapted for use on machinery and in building to counteract or absorb vibration.

Technical data on Sound Control will be found in Chapter 33.

INSULATION, Underground (p. 1099, 1116-1119)

Asbestos, asphalt, mineral wools, magnesia—used in conjunction with underground piping and conduits of concrete, tile or cast iron.

Technical data is contained in Chapter 43.

INSULATION, Pipes and Surfaces (p. 1094-1119)

Asbestos, magnesia, and mineral wools in loose fibrous forms, blankets, or in plastic forms and suitable for use in extremes of high or low temperature service; also hair and felts, and cork in loose bulk or in molded or plastic forms.

Technical data will be found in Chapter 43.

Some of these insulating materials are also used as refractory materials.

INSULATION, Duct (p. 1092-1115)

Various of the insulating materials which may be fabricated into board or slab forms, and various felts and fibrous materials have been adapted for use as duct insulation—as a duct liner or applied to the outer surfaces. Some have been utilized to construct the walls of the duct itself, serving the dual purpose of duct and insulation.

Technical data is contained in Chapter 43.

INSULATION, Window, Glass Block (p. 1120-1122)

Single-pane and double-pane insulating window sash, metal fabric insulating window screens, weather stripping for windows and for interior and exterior doors. Glass blocks for outside walls and partitions.

Manufacturer's products shown in this division are designed for specific applications. Consult the Index to Modern Equipment for additional products of these manufacturers.



Alfol Insulation Company Incorporated

155 East 44th St., New York, N. Y.

Agents in Principal Cities

HEAT INSULATION for ALL PURPOSES

ALFOL PRE-FABRICATED INSULATION PANELS FOR
TANKS, TOWERS, AND ALL TYPES OF HEATED EQUIPMENT



*Prefabricated
Panel—
At Right—
Applied to Tower*



- **Metal Jacketed Panels** containing insulation best suited for each particular condition.
- **Removable and Replaceable** by means of Lock-Joint construction.
- **Shop Fabricated** with Cut-outs for manholes and pipe connections.
- **Easily and Rapidly Applied** by any type of labor.
- **Trim Appearance** with minimum of up-keep.

FOR MORE DETAILED INFORMATION WRITE FOR ALFOL PANEL DATA BOOK

ALFOL HOUSE INSULATION BLANKET



99.4 per cent Pure Aluminum Foil spaced on three-ply thick paper vapor barrier sheet. Single and Double Layers insure spaced sheet to reduce conduction and convection. Applied between structural members or furring, Alfol Blankets give high insulation value at low cost.

Specifications

Description	Widths	Net Area per Roll	Net Weight per Roll
Type I.—1 Layer ALFOL	16"-24"	250 sq. ft.	17 lbs.
Type II.—2 Layer ALFOL	16"-20"-24"	200 sq. ft.	19 lbs.

See technical data on Table 1, Section C, Pages 91-94, this volume.

ALFOL RADIATOR REFLECTORS

ALFOL REFLECTORS behind radiators reduce heat loss through walls, save fuel. Temperature gradient to outside reduced 50 per cent.

TWELVE YEARS' SERVICE PROVES LASTING VALUE OF ALFOL

Armstrong Cork Company

Building Materials Division

Lancaster, Pennsylvania

Offices

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ATLANTA	CINCINNATI	JACKSONVILLE	NEW YORK	WASHINGTON, D. C.
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Distributors

APPLETON, WIS.	Northwestern Asbestos and Cork Insulation Co.	MANTOWOC, WIS.	Northwestern Asbestos and Cork Insulation Co.
CHARLESTON, W. VA.	Capital City Supply Company	NEW ORLEANS, LA.	H. T. Steffee
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LITTLE ROCK, ARK.	Fischer Cement & Roofing Company	TERRE HAUTE, IND.	The Hartmann Company
		TULSA, OKLA.	Kelley Asbestos Products Company

For detailed technical information, samples, and descriptive literature, ask any office or distributor. Specifications appear in Sweet's Catalogs for Architects and for Engineers and Contractors.

PRODUCTS—Armstrong's Corkboard, Cork Covering, Mineral Wool Board, Foamglas, Vibracork, Corkoustic, Cushiontone, Temlok, Insulation Sundries.

Corkboard

Insulating Efficiency

The thermal conductivity of Armstrong's Corkboard is 0.27 Btu per hour, per degree temperature difference, per inch thickness at 60 F mean temperature.

Armstrong's Corkboard conforms in all details to Federal Specification HHH-C-561a, March 9, 1939

Sizes and Thicknesses

Armstrong's Corkboard is furnished in rigid boards 12 in. x 36 in., 18 in. x 36 in., and 24 in. x 36 in., in several thicknesses: 1 in., 1½ in., 2 in., 3 in., 4 in., and 6 in.

Cork Covering

Armstrong's Cork Covering is made of pure cork in sizes to fit all standard pipe sizes. The inside surfaces of each piece are machined to assure an accurate fit, free from moisture-catching air pockets. Cork covering is rigid and will not sag. Thicknesses are. Ice Water (1.20 in. to 1.93 in.); Brine (1.70 in. to 3.00 in.); and Special Thick Brine (2.63 in. to 4.00 in.).

Armstrong's Fitting Covers are rigid and are designed to fit accurately all types of standard ammonia and extra heavy fittings, screwed, flanged, and welded.

Mineral Wool Board

Armstrong's Mineral Wool Board is a new permanent addition to the Armstrong line. It equals or exceeds Federal Specification HH-M-371 for board or block form insulation; has low thermal conductivity; is moisture-resistant, odorless; is easily handled and erected; possesses structural strength. Standard size 12 in. x 36 in.; thicknesses 1 in., 1½ in., 2 in., 3 in., 4 in.

Foamglas

Armstrong's Foamglas has a closed cellular structure which will not permit passage of air or moisture. It is efficient, moistureproof, fireproof, and offers effective, lasting insulation. This new type of insulation is made in standard 12 in. x 18 in. blocks; thicknesses 2 in., 3 in., 4½ in., 6 in. It may be used to insulate refrigerated storage rooms and equipment.

Engineering Service

For aid in the solution of any technical problems involving insulation, isolation, or acoustical treatment, and for literature and prices, get in touch with an Armstrong district office or distributor or the Armstrong Cork Company, Building Materials Division, Lancaster, Pennsylvania.

The Philip Carey Company

Manufacturers of Heat Insulation and Asbestos Products

Lockland

Sales



Offices

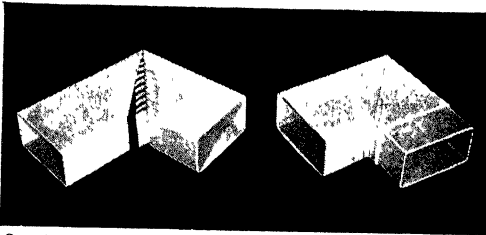
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CHATTANOOGA, TENN.
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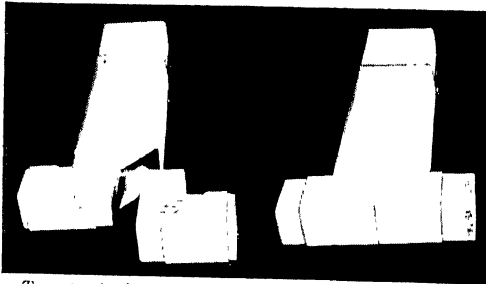
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DENVER, COLO.

DETROIT, MICH.
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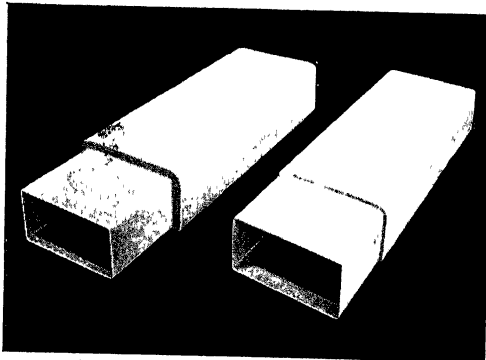
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Standard 90 deg Elbow assembly. Left: Core opened to show duct vanes Right: The completed fitting



Two standard 90 deg Elbows nested in a larger standard section to form a tee



Standard 1 in. and 1/2 in. thick Careyduct sections with core extended.

Careyduct is a new prefabricated insulated duct built entirely of asbestos. The double layer construction consists of an inner core of hard, rigid asbestos, and the outer jacket is made of multiple layers of a fine corrugated asbestos structure. The combination results in great strength, is an excellent insulator, and has a definite sound deadening effect.

Careyduct fittings are made from standard sections of duct, and may be made in the field with comparative ease by men without special training. A simple mitre cut plus a few standard accessories make a complete fitting thus keeping costs at a minimum. Prefabricated fittings may be ordered from the factory if desired.

The telescopic assembly method practically eliminates leaks that are commonly found in other construction.

The standard sizes of Careyduct are designed so that a combination of smaller sizes will exactly nest in a larger size. All tees and take-offs are a combination of ells and straight duct.

Grilles and dampers are installed according to the accepted standard practice. Careyduct gives high insulating value. It materially reduces the transmission of extraneous and equipment noises. Careyduct costs decidedly less than properly insulated metal duct and compares very favorably with sheet metal duct of standard quality.

For more detailed information write for Catalog and Erection Manual.

The Celotex Corporation

General Offices

120 South LaSalle Street, Chicago

CELOTEX

REG. U. S. PAT. OFF.

Celotex Cane Fibre Insulation products are made by felting the long, tough fibres of bagasse into strong, rigid boards. They are manufactured under the Ferox Process (patented) which effectively protects them from destruction by termites, fungus growth, and dry rot. They are integrally water-proofed which insures a non-hygroscopic insulation of low capillarity and enduring insulating efficiency.

Celotex Vapor-Seal Sheathing

An insulating, weather-resisting sheathing for use under any type of exterior. Surfaces and edges are moisture-proofed with a surface impregnation of asphalt.

Sizes: $2\frac{5}{32}$ in. thick; 4 ft wide; 8 ft, $8\frac{1}{2}$ ft, 9 ft, $9\frac{1}{2}$ ft, 10 ft and 12 ft long.

Center Matched—Available in the same thickness, in 2 ft x 8 ft T & G units for horizontal application.

Celotex Insulating Lath

Regular Insulating Lath—A cane fibre plaster base of high insulating efficiency. Surface provides a strong bond for plaster and the bevelled edges and ship-lap joint provide additional reinforcement.

Size: 18 in. x 48 in.; thicknesses: $\frac{1}{2}$ in. and 1 in.

Vapor-seal Insulating Lath—Same as above except for an asphalt vapor barrier on the back to prevent the penetration of moisture to the stud space.

Size: 18 in. x 48 in.; thicknesses: $\frac{1}{2}$ in. and 1 in.

Celotex Roof Insulation

Regular Roof Insulation—A cane fibre product possessing superior insulating properties. It prevents condensation; reduces roof heat transmission as shown by coefficients established in THE GUIDE; reduces roof movement due to contraction and expansion.

Size: 23 in. x 47 in.; thicknesses: $\frac{1}{2}$ in., 1 in., $1\frac{1}{2}$ in. and 2 in.

Vapor-seal Roof Insulation—Same as above except coated on all edges and surfaces with waterproof asphalt and made with an offset on all bottom edges to provide a network of channels which equalize air pressure to reduce roof blisters and buckling.

Size: 23 in. x 47 in.; thicknesses: 1 in., $1\frac{1}{2}$ in. and 2 in.

Cemesto

A completely fabricated fire and moisture resistant insulating composite wall unit. Consists of a Celotex cane fibre core surfaced on both sides with a $\frac{1}{8}$ in. layer of asbestos-cement. The established low thermal conductivity of the Celotex core, 0.33 Btu is maintained in the manufacture of Cemesto.

Sizes: 4 ft x 4 ft, 4 ft x 6 ft, 4 ft x 8 ft, 4 ft x 10 ft, 4 ft x 12 ft; thicknesses: 1 in., $1\frac{1}{2}$ in. and 2 in.

Celo-Siding

A weather-resistant, insulating, structural siding. Replaces wood or other sheathing materials and provides the exterior finish as well. Made of a Celotex cane fibre core that has been asphalt coated on all sides and edges. The weather side is additionally coated with a high grade asphalt into which mineral granules are firmly embedded.

Sizes: 2 ft x 8 ft, tongue and groove (long edges only); and 4 ft x 8 ft, 4 ft x 9 ft, 4 ft x 10 ft, 4 ft x 12 ft square edge, thickness: $\frac{7}{8}$ in.

Celo-Roof

An insulating roofing unit that combines efficient roof insulation with positive weather protection. Each unit consists of a specially formed vapor-sealed core of Celotex cane fibre encased in a heavy asphalt roofing felt surfaced with selected mineral granules.

Size: $15\frac{1}{2}$ in. wide by 7 ft $11\frac{1}{16}$ in. long, thickness: $\frac{7}{8}$ in.

Celotex Rock Wool Products

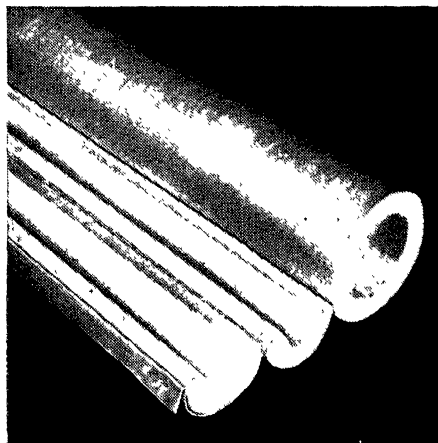
Available in the following forms—Loose, Granulated, Plain Batts, Paper-backed Batts, and Blankets. Celotex Rock Wool is made from the clean fibres of molten rock. It is incombustible and integrally waterproofed.

Q-T Ductliner

An acoustical material designed especially for duct lining in air conditioning systems. Absorbs duct noises. Made of rock wool and a special binder. Designed to withstand air duct humidity conditions. Is fire resistant and will not smoulder or support combustion. Thermal conductivity of 0.30

Ehret Magnesia Manufacturing Co.

Valley Forge, Pa.



85% Magnesia Pipe Coverings

A FULL RANGE OF INSULATIONS FOR HEATING AND VENTILATING

The Ehret Company furnishes a broad range of thermal insulations for practically every industrial and architectural requirement. For full details of Ehret products, see the Ehret Insulation Manual.

Ehret's 85 Per Cent Magnesia

Known for nearly half a century in the industrial field, Ehret's 85 per cent Magnesia Pipe Coverings and Blocks are efficient, economical and they last indefinitely. Pipe coverings are available in a full range of sizes and thicknesses, and blocks can be furnished in thicknesses up to 4 in. An ideal material for use on heated pipes or surfaces whose temperatures do not exceed 600 F.

OTHER HEAT INSULATIONS

In addition to 85% Magnesia insulation, the Ehret Company furnishes a full line of other heat insulating materials, in the forms of pipe coverings, flat and curved blocks, sheets, lagging, blankets, cements and loose fills. These materials include Enduro (high temperature), asbestos cellular, asbestos sponge felt, mineral wool and many other products for use on heated pipes and surfaces.

COLD INSULATIONS

Ehret insulations for use on cold pipes and surfaces are made in a variety of forms and

materials. Pipe coverings include cork, wool felt, frostproof and anti-sweat. Standard Hair Felt, Punched Hair Felt and Insulfelt, in roll form are used to insulate both curved and flat surfaces. Ehret's Eroduct is a special material in $\frac{1}{2}$ in. thickness that is applied to air conditioning and cold air ducts. Cork blocks, sheets and discs, as well as granulated cork are also furnished.

BUILDING INSULATIONS

For insulating the walls, floors and ceilings of buildings, Ehret's Heat Seal Wool is made in batts, strips, loose and granular forms. This material is high in insulating efficiency, is easy to install or apply and it will last indefinitely. Batts can be furnished with or without paper backing, as desired.

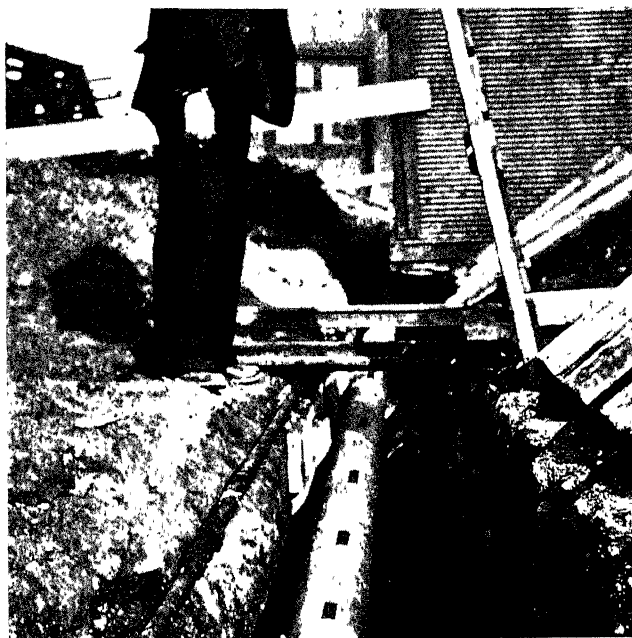
OTHER EHRET PRODUCTS

In addition to the insulations themselves, the Ehret Company can furnish insulation accessories such as water-proofing compounds, weathertight jackets, bands, wires, adhesives, sewing canvas, asbestos paper, wallboard and many other materials required for the application of insulations. Ehret packings and asbestos products as well as Durant Insulated Pipe (which is briefly described on the opposite page) are fully treated in the Ehret Insulation Manual. Write today for your copy of this 280 page handbook.



Ehret's Heat-Seal Wool Building Insulations

Two 3 in. steam lines of Durant Insulated Pipe, being installed one above the other in a narrow trench.



EHRET'S DURANT INSULATED PIPE

. . . for Underground and Outdoor Service

This unique system of pipe line protection consists of pipe that is insulated, sealed and protected *at our factory*, and shipped to the job ready for installation. Pipe lengths can be joined with screwed, flanged or welded fittings, and the system provides protection for expansion bends, joints, valves and similar pipeline appurtenances.

Field joints in Durant Insulated Pipe

are easy to make, and once made the backfill can be begun and the trench flooded for tamping.

Ehret's Durant Insulated Pipe will not crack or leak and moisture or water is permanently excluded by the thick, time-defying layer of high-melting-point asphalt that encloses all parts of the system. Write for the special Ehret D.I.P. folder—it gives full details.

Some Outstanding Advantages of Durant Insulated Pipe:

- | | |
|--|--|
| <ol style="list-style-type: none"> 1. Permanently waterproof. 2. Elimination of electrolysis and corrosion. 3. Requires no sub-drains as even complete water submersion does no harm. 4. In multiple lines, individual Durant pipes can be added, removed or replaced without disturbing others. 5. Minimum trenching and field work. | <ol style="list-style-type: none"> 6 No rollers or pipe supports required. 7. No breakage or waste of material during installation. 8. Tile or masonry protection not required. 9. Field costs are much lower than those of tile, tunnel and similar systems. 10. Insulation protection is absolutely dependable. |
|--|--|

The Eagle-Picher Lead Company

General Offices: American Building, Cincinnati, Ohio

Offices in Principal Cities



A Remarkable Insulating Wool Made From Minerals

Years ago Eagle-Picher pioneered a method of fusing and fiberizing carefully selected minerals into a dark gray insulating wool. This mineral wool is chemically inert. Fibers are mechanically strong, extremely resilient and flexible. They withstand expansion and contraction without loss of efficiency even at elevated temperatures.

From this mineral wool, Eagle-Picher has fabricated a long list of insulating products to meet a wide range of temperatures and operating requirements.

Eagle H-2 Loose Wool

A clean fill insulation that is highly efficient for temperatures to 1200 F. Averages considerably lighter in weight than many rock and slag wools—goes farther. Fibers are soft and flexible. Approved by Underwriters Laboratories as fireproof and a non-conductor of electricity. Retains physical and chemical stability in presence of water. Packed in 40-lb. bags.

Eagle 7-B Granulated Wool

Another grade of fill insulation that has all the advantageous properties of Eagle H-2 Loose Wool. It consists of small pellets averaging $\frac{1}{8}$ to $\frac{1}{2}$ in. in size. For all fill jobs in irregular spaces. May be poured. Packed in 40-lb. bags.

Eagle Low Temperature Felt

A highly efficient insulating material for subzero and low temperatures (to 400 F). Available in densities 6-lb to 8-lb per cu ft. Recommended for refrigerator rooms, trucks, refrigerators, stoves, etc. Sheds water. Extensively used in marine field

Paper Encased Batts and Blankets

These light-weight, sturdily constructed batts and blankets are easy to apply. Enclosed on four sides with paper, one



side of which is an approved vapor barrier. Strong tacking flanges. Quickly cut with knife or shears. Three thicknesses—Full-Thick, Semi-Thick and 1-in. For home use.

Eagle Super "66" Cement

A high-temperature plastic insulation. Easy to apply and trowels to a smooth finish. Actively inhibits rust. Will stick on any clean, heated surface. Dry coverage 50-55 sq ft per 100 lbs. 100 per cent reclaimable up to 1200 F. Packed in 50-lb bags.

Eagle Supertemp Blocks

An all-purpose high-temperature block insulation which will withstand elevated temperatures up to 1700 F without loss of efficiency or structural strength. Fibers are water-repellent. Light weight. Easily cut to fit irregularly shaped surfaces. Blocks withstand all normal vibration and abrasion encountered in use for which they are recommended. Available in all standard sizes.

Eagle Insulseal

A protective coating for Industrial Insulation Blankets, Supertemp, "66" Cement and other kinds of heat insulation. Provides a permanent seal that safeguards insulation against air infiltration, moisture, water, fumes; also against vibration and abrasion. Does not support combustion.

For more complete specifications and technical data on these and other Eagle Insulating Products, see Sweet's Engineering or Power Plant catalogs.

10807 Lyndon
at Meyers Road

INSULATION DUSTRIES CORPORATED DETROIT

**Detroit
Michigan**

ROCK WOOL INSULATION PRODUCTS

BUILDING INSULATION PRODUCTS

Loose Rock Wool (paper bags)
Granulated Rock Wool (paper bags)
Rock Wool in Rolls (any length or thickness)
Rock Wool Batts (cartons)
(with or without paper backs)
Rock Wool Batts (bags)
(without paper backs)

Insulation Industries Incorporated owns and operates one of the most modern, up-to-date Rock Wool plants.

Rock Wool is manufactured by a patented, precision process that produces a superior grade of Rock Wool. It is light in weight, has long, silky and resilient fibers. It is clean and free from foreign particles.

Rock Wool is indestructible and will last as long as the building itself. It is fire-proof, vermin and rodent-proof and is resistant to moisture.

BUILDING INSULATION

Rock Wool is suitable for all types of building insulation requirements.

It can be applied in the granulated form by the pneumatic method to existing homes or buildings.

For new construction or for unfinished attic or wall spaces, Batts are furnished either 15 x 23 in. or 15 x 48 in. and 2 or 4 in. thick and with or without paper backs, packed in cartons.

Long fiber Rock Wool in loose form is available packed in 35-lb paper bags.

RESULTS

Results obtained in all types of buildings, both old and new, show substantial

INDUSTRIAL INSULATION PRODUCTS

For

Stoves and Ranges
Water Heaters
Industrial Ovens
Bakery Ovens
Large Diameter Pipes
Boiler Settings, etc.

savings in fuel consumption with elimination of drafts and variation of temperatures between rooms and floors.

BLANKETS

Long fibered, especially treated Rock Wool, felted and secured between metal fabrics of different types. These blankets are made in standard sizes 24 in. x 96 in. and 24 in. x 48 in. and special sizes as required and any thickness from 1 in. to 8 in. Applicable to flat or curved surfaces.

INSULATING BLOCK

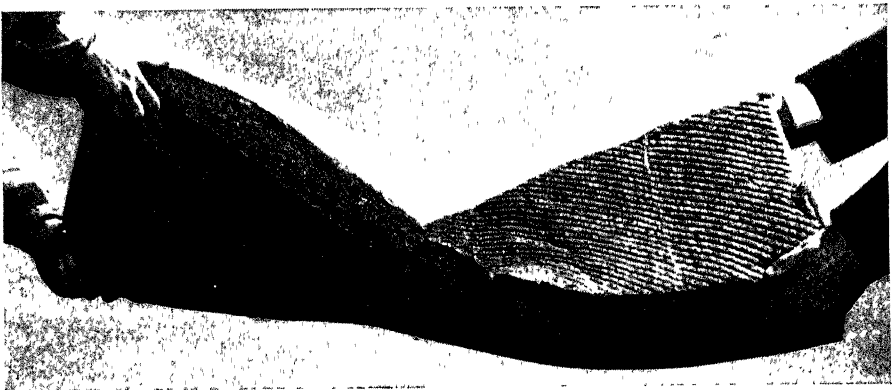
Rock Wool fabricated into sheet or board form from $\frac{1}{2}$ in. to 4 in. thick, 24 in. x 36 in. or special sizes, as required. This block is widely used for insulating boilers, ducts, tanks, stills, etc., and for domestic furnaces, boilers, ranges and hot-water tanks.

INSULATING CEMENT

For finishing block and blanket insulation. For temperature conditions from 100 to 2000 deg. Is very plastic and is quickly and easily applied.

SPECIFICATIONS

Write for complete information and details on Insulation Industries products.



A new type Rock Wool Batt, strong and durable yet flexible enough to meet any installation requirement

INSULITE

Division of
MINNESOTA AND ONTARIO PAPER COMPANY

General Offices
500 Baker Arcade Bldg., Minneapolis, Minnesota
TWENTY-NINE YEARS PROVEN DURABILITY

For 29 years engineers and architects have specified Insulite materials for structural uses, interior finish, duct lining, and for other thermal insulation and sound control work. Insulite materials have proved themselves practical through their performance on the job.

STRUCTURAL MATERIALS

Lok-Joint Lath—An insulating plaster base, fabricated from Ins-Lite or from Graylite. Patented "Lok" firmly locks the sheets between supporting members. Thickness: $\frac{1}{2}$ in. Size: 18 x 48 in.

Sealed Graylite Lok-Joint Lath—An insulating plaster base of Graylite, sealed on stud space side with an effective vapor barrier. Has patented "Lok" on long edges. Furnished in same thickness and size as Ins-Lite and Graylite Lok-Joint Lath.

Bildrite Sheathing is an asphalt-containing wood fiber insulating board manufactured under an exclusive process which provides increased strength and moisture resistance. It is $2\frac{5}{8}$ in. thick and has a distinctive gray-brown color. Thermal conductivity: 0.36 Btu per inch thickness. Each sheet is marked to indicate proper nail spacing. Available in sizes 4 x 8 ft up to 4 x 12 ft with all edges square. Also available in 2 x 8 ft size with interlocking joint on long edges. Used as a structural sheathing board and as a roof boarding.

Condensation Control—Where low outside temperatures and high inside humidities may occur, authorities recommend "sealing the warm side and venting the cold side" of the wall to prevent condensation. An adequate vapor barrier, Sealed Graylite Lok-Joint Lath, should be used on the warm (room) side of the wall thereby effectively reducing vapor transmission into the stud space. Bildrite Sheathing is designed to allow any surplus

vapor in the stud space to "breathe" or be vented to the exterior air. If vapor is trapped within the stud space and cannot escape through the sheathing, destructive condensation may occur.

INSULITE WALL OF PROTECTION

This construction consists of Bildrite Sheathing on the exterior of the frame work and either Lok-Joint Lath or Insulite Interior Finish Materials on the interior. Transmission coefficients (U) are shown below.

Exterior Finish and Sheathing	Interior Finish	
	No Insulation Between Studding	
	No plaster—Insulite Building Board, Interior Board, Tile Board, or Plank ($\frac{1}{2}$ in.)	Plaster ($\frac{1}{2}$ in.) on Lok-Joint Lath ($\frac{1}{2}$ in.)
Wood Siding, $2\frac{5}{8}$ in. Bildrite Sheathing	0.16	0.15

The above values are typical of results which can be obtained by utilizing Insulite materials in frame construction. For further (U) values refer to Chapter 4, pages 106 and 107.



Applying Bildrite Sheathing



Applying Lok-Joint Lath

INTERIOR FINISH MATERIALS

Ins-Lite Building Board—A wood fiber board with the light color of natural wood—burlap and linen textured surfaces. Thermal conductivity: 0.33 Btu/hr/sq ft/in./F; density: 16 lb/cu ft. Furnished in thicknesses of $\frac{1}{2}$ and $\frac{3}{4}$ inch and sizes of 4 x 7 ft to 4 x 12 ft. Also available in 6 x 8 ft, 6 x 12 ft and 8 x 12 ft sizes.

Graylite Building Board—An integrally treated asphalt containing wood fiber board of grayish brown color—burlap and linen textured surfaces. Thermal conductivity 0.35 Btu per inch thickness. Furnished in same thicknesses and sizes as Ins-Lite Building Board.

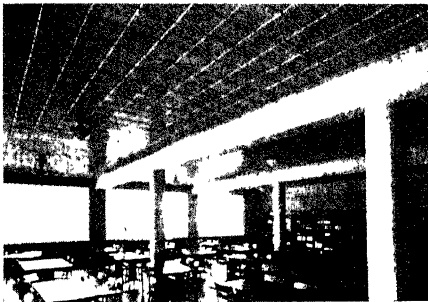
Smoothcote Interior Board—Coated Insulating Board with smooth, hard surface one side, having 68 per cent light reflection. Furnished in $\frac{1}{2}$ inch thickness only and in sizes of 4 x 7 ft to 4 x 12 ft.

Satincote Interior Board—Factory finished Insulating Board in colors buff, gray, coral and green. Light reflection from 64 per cent for green to 80 per cent for the buff color. Requires no further decoration. Highly resistant to abrasion and easily washable. In $\frac{1}{2}$ inch thickness and in sizes of 4 x 7 ft to 4 x 12 ft.

TileBoard—Available in Smoothcote and Satincote. TileBoard is furnished with the Lok-Grip Joint that permits concealed nailing and which together with the Lok-Pin (a flat diamond shaped metal dowel) definitely and mechanically safeguards against any falling units even though no face nailing is used.

Smoothcote and Satincote TileBoard available in $\frac{1}{2}$ inch thickness and sizes of 12 x 12 inches to 16 x 32 inches.

Plank—Available in Smoothcote and Satincote. Plank has the Lok-Grip joint which permits concealed nailing and is beveled and beaded both long edges. Smoothcote and Satincote Plank furnished in $\frac{1}{2}$ inch thickness, widths of 8 to 16 inches and lengths of 8 to 12 ft.



*Acoustilite or Fiberlite effectively
quiet and control sound*

Acoustilite—A high efficiency acoustical material for sound control. Coefficient of sound absorption, at 512 cycles, is 0.79 when mounted on solid background and 0.80 when on furring strips. Noise reduction coefficient is 0.65 when mounted on solid background and 0.75 when on furring strips. Factory painted in buff, (light reflection 77 per cent) and in white (light reflection 80 per cent). Units have a butt joint and are beveled on four edges. Thickness, $\frac{3}{4}$ in.; sizes, 12x12 in. to 16x32 in.

Fiberlite—An efficient sound absorptive and decorative material. Coefficient of sound absorption, at 512 cycles, is 0.53 when mounted on a solid background and 0.72 when on furring strips. Noise reduction coefficient is 0.55 when mounted on solid background and 0.65 when on furring strips. Factory painted in buff (light reflection 77 per cent) and in white (light reflection 80 per cent). Units have a butt joint and are beveled on four edges. Thickness, $\frac{1}{2}$ in.; sizes, 12x12 in. to 16x32 in.

HardBoard Products

HardBoard materials are tough, durable, grainless, pressed wood fiber boards with a hard, smooth surface. Available in a range of densities from 55 to 68 lb/cu ft. Thicknesses are from $\frac{1}{4}$ to $\frac{5}{16}$ in. and sizes of 4 x 2 ft to 4 x 12 ft.

Industrial Insulation

Industrial Insulation is a wood fiber board for use in all types of manufacturing industries producing items such as refrigerators, coolers, showcases, brooders, partitions and cabinets.

It can be cut-to-size and fabricated to customer's specifications. Three types of industrial board are available.

Lowdensite Industrial Board—A 10 to 14 lb density board with an average tensile strength of 100 lb/sq in. and an average conductivity of 0.30 Btu/hour/sq ft/F/inch thickness.

Ins-Lite Industrial Board—A 14 to 18 lb density board with an average tensile strength of 250 lb/sq in. and an average conductivity of 0.33 Btu/hour/sq ft/F/inch thickness.

Graylite Industrial Board—Differs from two above products in that it has an integral asphalt treatment which provides increased strength and moisture resistance as well as minimum thickness and linear expansion. A 16 to 20 lb density board with an average tensile strength of 350 lb/sq in. and an average conductivity of 0.35 Btu/hour/sq ft/F/inch thickness.

Johns-Manville

Executive Offices: 22 East 40th Street, New York, N. Y.

Offices in All Large Cities



Johns-Manville Home Insulation

Johns-Manville Rock Wool Home Insulation is a light, fluffy mineral wool, highly efficient in heat-proofing practically any building, old or new. It is durable, rot-proof, fire-proof and odorless, and will not corrode or settle. Full stud thickness of this material will cut fuel costs up to 30 per cent in winter and help keep rooms up to 15 deg cooler in hottest weather. J-M Rock Wool Home Insulation is furnished in two forms: for new construction,



Applying J-M Super-Felt Type B batts in new home

in easily handled batts, for existing buildings, in nodulated form to be installed pneumatically.

For New Construction J-M Super-Felt Type B Batt

Super-Felt Type B Home Insulation is furnished in pre-fabricated batts of uniform thickness and density, in both full stud thickness and semi-thick, in sizes 15 x 23 in. and 15 x 48 in., designed to fill

completely the space between studs, joists and rafters on the usual 16 in. centers. The sturdy felted "wool" is strong enough to be handled rapidly without damage. The batts are backed with waterproof, vapor-resistant paper, extending on both the long sides in 1½ in. wide flanges, by which the batt is fastened in place and which also aid in sealing the joints. This backing protects against penetration of moisture from wet plaster and also resists infiltration of moisture vapor from the house into the wall.

As a further protection against moisture, the felted wool is also waterproofed.

Super-Felt may also be obtained in blanket form, in Thick, Medium and 1 in. thicknesses. The blankets have a waterproof vapor barrier paper on one side and a permeable kraft paper on the opposite side, cemented together along the long edges to form a strong nailing flange.

For Existing Homes and Buildings Type A "Blown" Rock Wool

Type A Rock Wool is blown pneumatically into the spaces between studs in outer walls and between rafters or joists in roofs or attic floors. Insulation thickness in walls corresponds to stud depth, approximately 3½ in.; the density, approximately 5 to 8 lb per cu ft, assures maximum thermal efficiency. This type of insulation is installed only by Approved J-M Home Insulation Contractors, who are equipped with the necessary apparatus and trained crews.

Write for Details

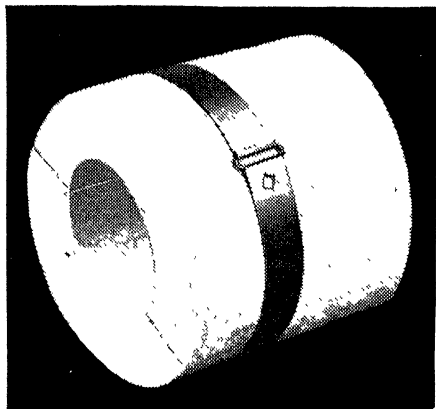
Complete information on all types of J-M Rock Wool Home Insulation will be furnished on request.

J-M Airacoustic Sheets for lining Air-Conditioning Ducts

J-M Airacoustic Sheets, for duct linings of air conditioning systems, are flame-proof, highly sound-absorbent and mois-

ture-resistant, with a surface which will not materially increase friction losses in the duct system. Write for Bulletin AC-23A.

Johns-Manville Pipe and Boiler Insulation



J-M 85% Magnesia Pipe Insulation

J-M Pre-Shrunk Asbestocel Pipe Insulation

J-M Pre-Shrunk Asbestocel is a radically improved insulating material for hot water or low pressure steam piping, which, since it is made of moisture-proofed asbestos paper, minimizes objectionable shrinkage.

Supplied in canvas or asbestos paper finishes. All types furnished in 3-ft section in standard thicknesses of 2 to 8 plies, each ply approximately $\frac{1}{4}$ in. thick, for all commercial pipe sizes.*

J-M 85% Magnesia

Recommended as the most widely used insulation of the molded type for temperatures up to 600 F. Pipe insulation is furnished in sectional or segmental form for all commercial pipe sizes,* in thicknesses up to 3 in. Blocks are 3 in. by 18 in. and 6 in. by 36 in., flat or curved, from 1 in. to 4 in. thick. Minimum thickness for curved blocks, $1\frac{1}{4}$ in.

J-M Pre-Shrunk Wool Felt Pipe Insulation

Due to its Dual-Service Liner—an asphalt-saturated felt—J-M Pre-Shrunk Wool Felt is equally effective and durable on either hot or cold water service piping. By the use of moisture proofed felts, shrinkage troubles have been minimized.

Supplied in the regular canvas finish, it is furnished in 3-ft sections in thicknesses of $\frac{1}{2}$ in., $\frac{3}{4}$ in., 1 in., Double $\frac{1}{2}$ in., and Double $\frac{3}{4}$ in., for all commercial pipe sizes.*

J-M Asbesto-Sponge Felted Pipe Insulation

Recommended on all high pressure steam piping at temperatures up to 700 F where insulation may be subjected to rough usage or where maximum efficiency and durability are desired. Furnished in 3-ft sections up to 3 in. thick, for all commercial pipe sizes.

J-M Superex Combination

Superex Combination Insulation (an inner layer of high temperature Superex and an outer layer of 85% Magnesia) is recommended where temperatures exceed 600 F. Superex and Magnesia are both furnished in sectional and segmental pipe covering, and in block forms.

J-M Asbestocel Sheets and Blocks

Asbestocel Sheets and Blocks are used for insulating warm-air ducts, flues, heater casings and fan housings in the ventilating system. Temperature limit 300 F. Furnished 6, 9, 12, 18 and 36 in. wide by 36, 48, 72 and 96 in. long, from $\frac{1}{4}$ in. to 2 in. thick

J-M Rock Cork Sheets and Pipe Insulation

J-M Rock Cork is made of mineral wool and a moisture-proof binding ingredient molded into sheets for insulating refrigerated rooms and air conditioning ducts; and into sectional pipe insulation with an integral waterproof jacket, for all low temperature service. It is strong, durable, and will not support vermin. Because of its unusual moisture resistance, its high insulating efficiency is maintained in service.

Furnished in sheets 18 in. by 36 in., in 1, $1\frac{1}{2}$, 2, 3 and 4 in. thicknesses; also 18 in. by 18 in. by 1 in. thick. In lagging form, for curved surfaces, supplied 18 in. long by $1\frac{1}{2}$, 2, 3 and 4 in. thick, 2 to 6 in. wide, depending on diameter. In pipe covering form, in ice water, brine and heavy brine thicknesses, for all commercial pipe sizes.

Details on Request

Write for complete information on any Johns-Manville insulating material.

*Can also be supplied in sections to fit straight runs of copper pipe or tubing with outside diameter $\frac{3}{8}$ in. and larger.

KIMBERLY-CLARK CORPORATION

ESTABLISHED 1872 (Building Insulation Division) NEENAH, WISCONSIN

KIMSUL* is a trade-mark of Kimberly-Clark Corp. for its brand of laminated and asphalted, compressed insulation.



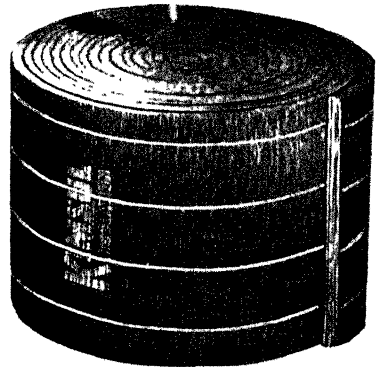
**High in Thermal Efficiency . . . Easy to Install . . . Long-Lasting . . .
Moisture Resistant . . . Clean . . . Light in Weight . . . and Low in Cost!**

KIMSUL*, is a wood fibre product, made in long, flexible blankets composed of many creped layers or plies, providing a maximum number of dead air cells for efficient insulation. Being flexible and extremely light in weight, it is easy to install. Each

blanket is stitched with rows of strong twine running the length of the blanket. This unique feature holds the installed KIMSUL blanket securely in place—prevents sagging or "packing down" inside the walls.



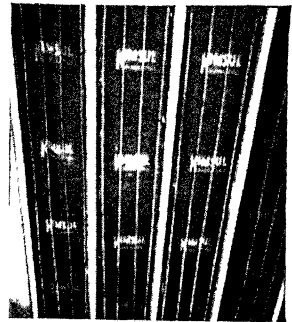
KIMSUL comes compressed, packaged as at left . . . is expanded on job to about 5½ times packaged length (right), saving on handling time, storage space and transportation cost



Strong stitching keeps KIMSUL at its proper density, prevents it from sagging, sifting and settling. Once in place, KIMSUL stays "put."



KIMSUL Insulation is easy to cut to exact size, fits out-of-the-ordinary spaces as neatly and as easily as it fits standard spacings.



Sloping roofs present difficult insulation problems, but even in spots like this, one man can usually install KIMSUL quickly and easily.

Manufactured by the Kimberly-Clark Corporation, makers of wood fiber products since 1872, KIMSUL* Insulation is one of the most efficient insulating materials ever developed.

Thermal Insulation: For walls, floors, ceilings and roofs. "k" Factor is .27 Btu/hr/sq ft/degrees F/inch—J. C. Peebles.

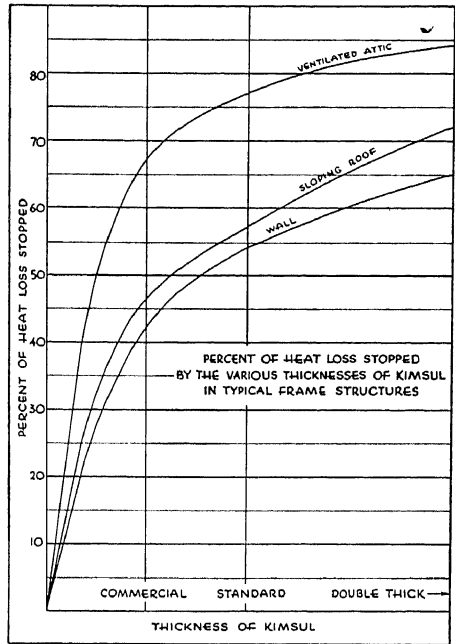
Acoustical Insulation: For walls and ceilings. Average coefficients of absorption: Commercial thickness—.41. Standard thickness—.59. Double-thick—.67.

Sound-Deadening Insulation: For partitions and floors.

Physical Characteristics: KIMSUL Insulation is a laminated and asphalted wood fiber flexible blanket insulation . . . resistant to water . . . extremely light in weight (1.5 lbs per cu ft) . . . faced with a tough waterproof cover.

Available in 3 Thicknesses: Commercial Thick (nominally one-half inch) . . . Standard Thick (nominally one inch) . . . Double Thick (nominally two inches) . . . Furnished in correct widths for standard stud spacings.

Vapor Seal: Separate sealing recommended wherever vapor seal is required.



Graph shows how effectively KIMSUL reduces heat flow through typical frame structures. Note that greatest proportion of heat losses are stopped by the first inch of KIMSUL.

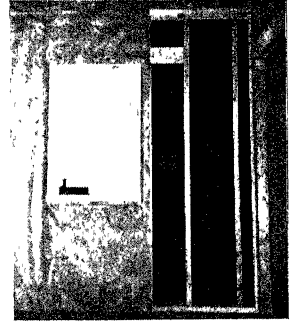
*Reg. U. S. & Can. Pat. Off.



Pipes and conduits don't interfere with the insulating efficiency of KIMSUL. It works around corners, tucks snugly into "tight" places.



Used for caulking around window frames and doorways, odd pieces of KIMSUL add to effectiveness of insulation job, eliminate waste.



When a Vapor Seal is needed to guard against condensation within walls, it should be installed as shown, separate from the insulation.

Mundet Cork Corporation

65 S. Eleventh St.

INSULATION DIVISION

Brooklyn, N. Y.

Manufacturers of Corkboard, Cork Pipe Covering, Compressed Machinery Isolation Cork, Natural Cork Isolation Mats, and all kinds and varieties of Cork Specialties.

Authorized contractors for high temperature insulation

Mundet Branches

ALBANY, N. Y.	CHICAGO, ILL.	HOUSTON, TEXAS	PHILADELPHIA, PA.
ATLANTA, GA.	CINCINNATI, OHIO	KANSAS CITY, MO.	ST. LOUIS, MO.
BROOKLYN, N. Y.	DALLAS, TEXAS	LOS ANGELES, CALIF.	SAN FRANCISCO, CALIF.
BOSTON (No. CAMBRIDGE), MASS.	DETROIT, MICH.	NEW ORLEANS, LA.	SYRACUSE, N. Y.

Mundet Distributors are Located in the Following Cities—Names and Addresses on Request

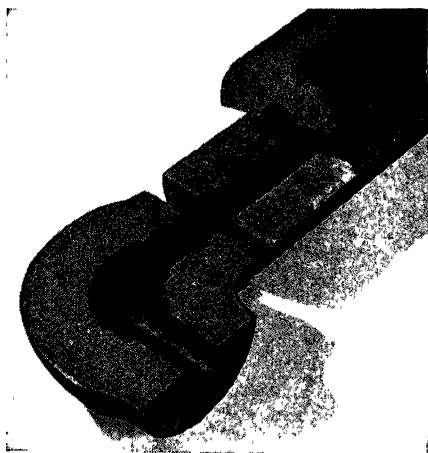
AMANA, IOWA	HARTFORD, CONN.	OKLAHOMA CITY, OKLA.	SEATTLE, WASH.
BALTIMORE, MD.	JOHNSON CITY, TENN.	PORTLAND, OREGON	TUCSON, ARIZ.
BUFFALO, N. Y.	MEMPHIS, TENN.	PROVIDENCE, R. I.	TULSA, OKLA.
CHARLOTTE, N. C.	MINNEAPOLIS, MINN.	RICHMOND, VA.	UTICA, N. Y.
CLEVELAND, OHIO	NASHVILLE, TENN.	ROCHESTER, N. Y.	YOUNGSTOWN, OHIO
DENVER, COLO.	NORFOLK, VA.	SALT LAKE CITY, UTAH	

Mundet "Jointite" Corkboard

—for all low temperature insulation and for acoustical correction. 100 per cent pure cork, fabricated in accordance with U. S. Government Master Specifications and unsurpassed in its field. Sold in standard 12 in. x 36 in. sheet. Standard thicknesses, 1/2 in., 1 in., 1 1/2 in., 2 in., 3 in., 4 in., 6 in.

Mundet "Jointite" Cork Pipe Covering

Shown below, with fitting cover. Protects all types of low temperature lines. Made in 3 thicknesses, with complete line of standard covers, suitable for pipes carrying sub-zero to 50 F temperature.

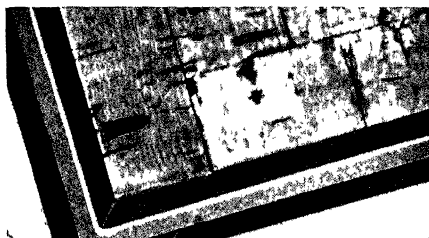


Section of Mundet Moulded Cork Pipe Covering, with Fitting. The pipe covering is made in sections 36 in. long, to fit all sizes of pipes.

Mundet Cork Vibration Isolation

Machinery vibration encountered in heating and ventilating work is effectively controlled by the use of Mundet Natural Cork Isolation Mats. These consist of blocks of pure cork, held together within a rigid steel frame or bound with asphalt

paper applied with hot asphalt top and bottom. Mundet steel bound mats are usually used under exposed mounts; asphalt paper bound mats under concrete foundations of the envelope type. Mats are made to fit under any type of machine foundation. For loads exceeding 2000 lb per square foot, we manufacture Mundet Machinery Isolation Cork, which is a board form of compressed granulated cork, available in 3 densities. All types of isolation are furnished in 1 in., 1 1/2 in., 2 in., 3 in., 4 in., and 6 in. thicknesses, depending on class of service



Above close-up of Mundet Natural Cork Isolation Mat shows how the blocks of cork are held together within a steel frame.

Engineering and Specification Service

Our engineering department is at the service of Architects and Engineers, to assist and advise in the preparation of specifications pertaining to cork. This service is also available without obligation to any one who has a low temperature insulation or a vibration isolation problem. Our complete catalogue will be sent on request. It is replete with information and data of value to every specification writer whose field touches our products.

Mundet Contract Service

Covers the complete installation of our products, in accordance with best established practice. Divided responsibility is avoided. Materials and workmanship are guaranteed.

The Pacific Lumber Company

PALCO WOOL INSULATION

100 Bush Street
SAN FRANCISCO

35 E. Wacker Drive
CHICAGO

5225 Wilshire Blvd.
LOS ANGELES

122 East 42nd St.
NEW YORK

HOUSE INSULATION

INSTALLED IN
CEILINGS AND WALLS

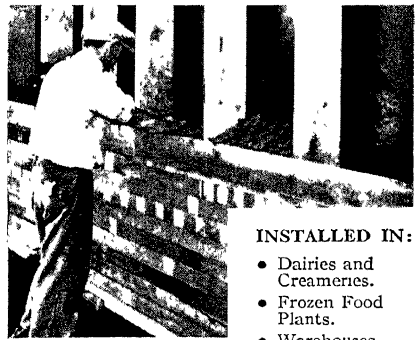


TRADE MARK REG U S PAT OFFICE

COLD STORAGE INSULATION



A full 4 inches of
PALCO WOOL
provides maximum
insulation—insu-
rance against par-
tially insulated homes



INSTALLED IN:

- Dairies and Creameries.
- Frozen Food Plants.
- Warehouses.
- Refrigerators.
- Pre-cooling Plants.
- Ice Plants.
- Fur Vaults.
- Fruit and Produce Storage, etc.

Quickly and easily
installed by hand-
pack methods

**Flame Proof
SAFERIZED
Process**

EIGHT POINTS OF PALCO WOOL SUPERIORITY

1. Thermal Efficiency: The established conductivity of PALCO WOOL is .26 Btu per hour per sq ft per inch of thickness per degree F difference in temperature by the Flat Plate Method.

2. Non-Settling: The fibres of PALCO WOOL possess such resilience that no settlement in a wall can occur under the most severe conditions of vibration.

3. Moisture Resistant: The fibres of PALCO WOOL are entirely lacking in capillarity and have little attraction for moisture, enabling it to remain dry and efficient when in use.

4. Permanent: The inherent anti-septic qualities of PALCO WOOL make the existence of fungus impossible. The fibres retain their resilience indefinitely.

5. Vermin Repellent: PALCO WOOL is distasteful and repellent to rodents and insects.

6. Fire Resistant: PALCO WOOL, like the Redwood bark it comes from, is inherently fire resistant. As an additional protection it is *Saferized* to make it flame-proof.

7. Odor Proof: PALCO WOOL is odorless itself and does not absorb or give off odors.

8. Economical: PALCO WOOL is light in weight and low in density, offering exceptional thermal efficiency per dollar invested.

WRITE FOR INSULATION MANUALS

- House Insulation Manual.
- Cold Storage Manual.
- Frozen Food Locker Plant Manual.
- How to Build a Plant Manual.

Get your copies today.

The Ruberoid Co.

INSULATING PRODUCTS

Executive Offices

500 Fifth Avenue, New York, N. Y.

Divisional Offices

NEW YORK CHICAGO BOSTON (Millis) ERIE BALTIMORE MINNEAPOLIS MOBILE

Today, Ruberoid materials for heating and power equipment are safe-guarding insulation efficiency in hundreds of plants, factories and buildings—giving maximum results with minimum cost.

The Ruberoid line of insulation products is complete. These products are of proved merit, high efficiency and of a type to meet every need economically. They include pipe coverings and blocks for temperatures

from 350° F to 2100° F; Woolfelt pipe covering for hot or cold water conduits; asbestos papers for wrapping furnace pipes, protecting air conditioning; specialties such as high temperature cements, millboard, rollboard, rock wool bats and blankets. A complete Insulation Guide, which will enable you to choose the proper product for the job quickly, will be gladly forwarded upon request.

Product	Temp. Limit	Suggested Use
"48" Copr-Fibre Block	to 2100° F	Mineral Wool blocks having unusually high insulating properties.
Hi-Temp	to 1900 F	Protective inner layer for high temperature insulations
Sponge felt	to 700 F	For vibrating pipes and underground insulation— excellent efficiency.
85 per cent Magnesia	to 600 F	Combines efficiency and reasonable cost— General use in industrial work
Imperial	to 600 F	Rugged, efficient—wide range of applications
WatcoCell	to 300 F	For a low-cost medium pressure industrial steam line
Air Cell	to 380 F	Standard insulation for residential pipes
Woolfelt	to 200 F	For cold and hot water lines Recommended especially for air conditioning work.
Anti-Sweat	to 120 F	For cold water lines to prevent condensation
Frost-proof	30 F to 100 F	To assist in the prevention of freezing in circulating water pipes exposed to cold.

In addition to "48" Copr-Fibre Blocks all the above products are also made in sheet and block form for insulating flat or irregular surfaces such as tanks, breechings, furnaces, etc.

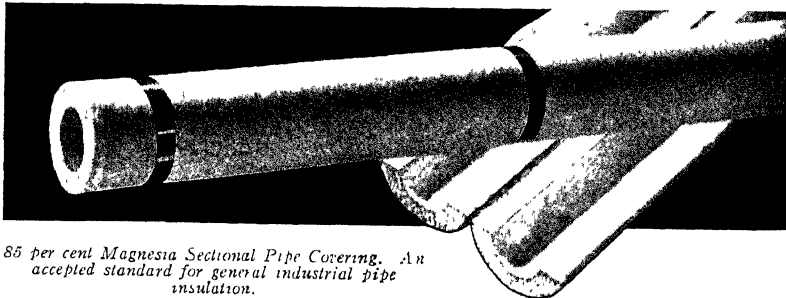
"48" Copr-Fibre Blocks

Copr-Fibre Blocks are processed from minerals having unusual insulating properties and high temperature inorganic binding materials. There are two major blocks: No. 18 for indirect temperature service up to 1800° F, and No. 20 for high temperature service to 2100° F and high compressive loads. Both are available in

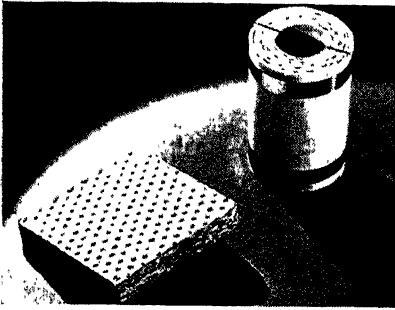
standard sizes and in thicknesses up to 4 in. Most popular of standard sizes are 6 x 12 in., 6 x 24 in., 6 x 36 in., 12 x 18 in., 12 x 24 in., 12 x 36 in., 18 x 24 in. A comparison of compressive strength, modulus of rupture, weights per board feet and linear shrinkage follows.

	Strength per Sq In.	Modulus of Rupture	Weight per Board Ft	Linear Shrinkage
No. 18	20	55 lbs	1.85	2.5%
No. 20	83	52 lbs	2.35	3.0%

Both No. 18 and No. 20 blocks are also available with a refractory surface.

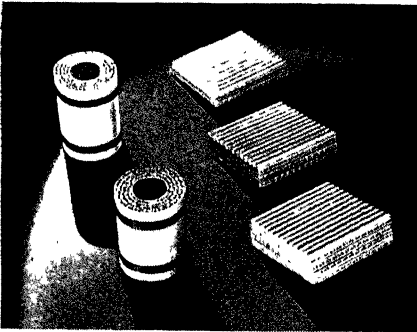


85 per cent Magnesia Sectional Pipe Covering. An accepted standard for general industrial pipe insulation.

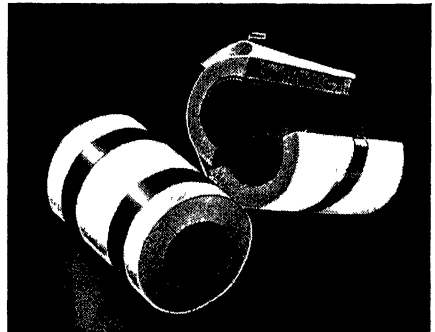


Imperial Pipe Covering

This is a laminated asbestos paper insulation that has been indented to use 22 laminations of asbestos paper per inch thickness. Its efficiency makes it satisfactory for most medium pressure steam work in industrial plants. Its construction makes it ideal for vibrating conditions. It is recommended for temperatures to 600° F. Being an asbestos felt laminated material it is used on vibrating pipes or where hard service is expected. Will withstand water conditions for underground piping. Excellent as an industrial, oil refinery and synthetic rubber plant insulation.



Air Cell Pipe Covering—A low-cost insulation for residential use.



Woolfelt Pipe Covering—For the insulation of pipes carrying hot or cold water—also prevents condensation under normal operating conditions.

Ruberoid Insulating Cements

For the finishing of sheet and block insulation and the insulating of irregular surfaces, such as valves, unions, flanges, etc., the Ruberoid line of insulating cements is complete. This group of cements not only uses as its base asbestos, but also takes advantage of such excellent natural products as magnesia, mineral wool and Vermiculite

Asbestos Cements—Factory Prepared—Grades AA, A, HF.

Asbestos Cements—Mine Run—Grades 115, 214.

Magnesia Cement—85 per cent Magnesia.

High Temperature Cement—Grade H.T.

Mineral Wool Cement—"48" High Temperature.

Vermiculite Cement—Grade A-11.

Ruberoid Asbestos Insulating Papers and Millboard

Asbestos Paper

Made of pure asbestos, fire-resisting. May be obtained in 6, 8, 10, 12, 14, 16 and 32 lb weights.

Asbestos Corrugated Paper

Efficient for insulating warm air pipes and ducts. 36 in. wide. Rolls contain 250 sq ft.

Asbestos Millboard

A rigid board of exceptional strength and whiteness. Cuts and drills easily. For temperatures to 1000° F. Sheets 42 x 48 in.



Reynolds Metals Company

Federal Reserve Bank Building

Richmond, Virginia

NEW YORK

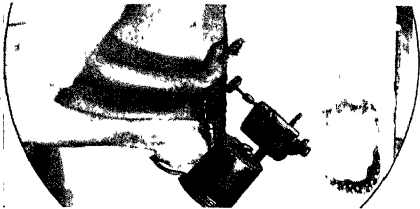
CHICAGO

LOUISVILLE

SAN FRANCISCO

REYN-O-Cell

CELLULAR FIBRE INSULATION



"Reyn-O-Cell is incombustible. Even an acetylene torch (approximately 1500 F temperature) will not cause flaming. Reyn-O-Cell meets all fire test requirements of Federal Specifications."

Reyn-O-Cell stops up to 73 per cent heat flow and permits complete air circulation around framing. Thermal conductivity is .24 Btu per hour, per square foot, per 1 F, per inch thickness. (Authority—Prof. J. C. Peebles, Armour Institute of Technology).

Reyn-O-Cell is one of the most efficient barriers to the passage of heat that is commercially available today. It consists of heat retarding dead air cells. There are myriads of minute and hollow cellulose fibres, entwined and interlocked into a flexible, clean, resilient and light-weight mass.

AIR CIRCULATES FREELY

Reyn-O-Cell permits free circulation of air on both sides of the insulation, thus allowing rapid evaporation of any moisture which may occur. Possible damp-rot, decay or other damage to structural materials is thereby minimized.

RODENT AND VERMIN PROOF

Reyn-O-Cell blanket type insulation insures utmost cleanliness, not only during installation, but during the lifetime of the structure. It is not subject to attack by rodents, and does not harbor vermin or other insects. It is odorless, and will not decay.

WATER-REPELLENT AND FLAME PROOF

Reyn-O-Cell will not absorb water or moisture. It has successfully withstood flame tests up to 1500 F.

REYN-O-CELL is one of the most effective sound absorption materials

APPROVED AND ACCEPTED

Reyn-O-Cell is manufactured under constant United States Government inspection and in strict accordance with Department of Agriculture specifications. It is approved for home and industrial insulating purposes by Federal, State and Municipal bureaus, builders, architects, and heating engineers throughout the United States.

Reyn-O-Cell is ideally suited for equipment insulation. It can be furnished cut to size and in special widths up to 60 inches.

COSTS LITTLE TO INSTALL

Furnished in convenient blankets, or rolls, **Reyn-O-Cell** is adaptable to all constructions without expensive cutting or waste. **REYN-O-CELL** does not settle, sag or pack. For existing homes, as well as for walls, ceilings or roofs of new structures it provides maximum insulating efficiency. Labor costs for installation are exceptionally low.



REYN-O-CELL Is Easily Installed

Send for A.I.A. folder 37-a-1 describing **Reyn-O-Cell**; also 20-D-1 describing **Reyn-O-Lath Plaster Reinforcement and Plaster Base**; and 14M describing **Reyn-O-Wall System of 2 in. Non-Load Bearing Partitions**.

Wood Conversion Company

First National Bank Building, St. Paul, Minn.

NEW YORK

CHICAGO



TACOMA

DALLAS

BALSAM-WOOL AND NU-WOOD INSULATIONS

BALSAM-WOOL

Sealed Insulation
Acoustical Blanket
Sound Deadening
Industrial Insulation
Refrigerator Insulation

NU-WOOD

Kolor-Fast Tile
Kolor-Fast Plank
Kolor-Fast Board
Kolor-Fast Wainscot
Kolor-Fast Sheathing

NU-WOOD

Lath
Roof Insulation
Industrial Insulation
Refrigerator Insulation
KOLOR-TRIM Pre-decorated Moldings

BALSAM-WOOL—The Double Value Sealed Insulation

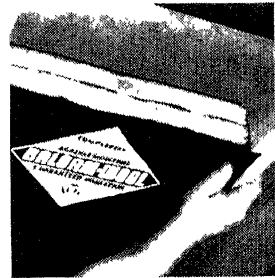
The basic rightness of Balsam-Wool insulation principles has been recognized for 20 years. Constant improvement has made this insulation an acknowledged leader. Today, the new DOUBLE-VALUE BALSAM-WOOL offers greater moisture protection, increased efficiency, and increased thickness. In addition, Balsam-Wool SEALED insulation provides such outstanding Double Advantages as Double Sealing, Double Moisture Barriers, Double Wind Barriers, Double Air Spaces, Double Bonding, Double Fastening.

Balsam-Wool is an insulating mat of fleecy wood fibers, enclosed between a protective covering of double layers of asphalted craft, chemically treated to resist fire, rot, termites and vermin—92 per cent of the mat volume is dead air.

Balsam-Wool SEALED Insulation is fabricated at the factory to a controlled density of 2.2 lb per cubic foot. The mat has a coefficient of 0.246 Btu per hour, per square foot, per 1 degree F difference in temperature, per 1 in. thickness.

As applied, factory efficiency is assured. The Spacer Flange on each edge folds over and is fastened to framing members with a staple hammer, assuring important air space front and back.

Double-Value Balsam-Wool is available in two new increased thicknesses—STANDARD and DOUBLE-THICK, in widths of 16, 20, 24 and 33 inches. Wall-thick Balsam-Wool is available in widths of 16, 20 and 24 inches



Balsam-Wool Spacer Flange



Application is quick and easy

NU-WOOD INTERIOR FINISH—STRUCTURAL INSULATION

Nu-Wood Kolor-Fast and Sta-Lite Interior Finish (Tile, Plank, Board and Wainscot) is applicable either to new construction or to existing buildings. It offers varied and pleasing decoration, also insulation and acoustical value.

Nu-Wood Insulating Lath has several times the bonding strength of wood lath—continuous surface eliminates dirty lath

marks, reduces cracks, V-joint resists trowel pressure in both directions—assures unbroken insulation value.

Nu-Wood Insulating Sheathing is surfaced on both sides with double coats of special moisture proofing compound. Large board—speed erection—stronger, windproof, insulated construction.

United States Gypsum Company

General Offices: 300 W. Adams Street, Chicago, Ill.

INSULATION PRODUCTS

Blanket

Decorative

Structural

Blanket



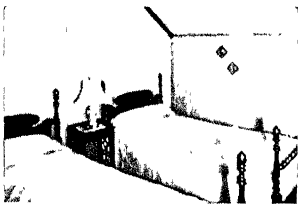
Red Top Insulating Blanket

RED TOP INSULATING BLANKETS

—Made in three thicknesses: one inch, medium and thick, in rolls of 125, 75 and 50 square feet (net area), respectively. Also available in bats 3 feet long in same thicknesses. Light-weight *RED TOP INSULATING WOOL blanket is wrapped in an efficient asphalt-type vapor barrier toward warm side and a tough, perforated, vapor permeable paper on cold side, which prevents possible accumulation of moisture within blanket.

*Red Top Insulating Wool is a Fiberglas product
Patent No. 345156.

Decorative



Decorative

WEATHERWOOD PLANK—Manufactured in widths of 8, 10, 12 and 16 inches and in lengths 6, 8, 10 and 12 feet, $\frac{1}{2}$ inch thick. "Ogee" edge on long edges (see cut) conceals nails and fully compensates for movement in the board because of expansion or contraction. Shipped in a blend of gray and tan shades in bundles of one size. When combined in variations in shade and width, Weatherwood Plank produce maximum values in both insulation and decoration.



Ogee Edge

WEATHERWOOD TILE Available in the following sizes: 12 x 12 inches, 12 x 24 inches, 16 x 16 inches and 16 x 32 inches in $\frac{1}{2}$ inch, $\frac{3}{4}$ inch and 1 inch thicknesses and 12 x 48 inches, 24 x 48 inches, 24 x 96 inches, 48 x 48 inches and 48 x 96 inches in $\frac{3}{4}$ inch only. The "Ogee" design on all edges enhances the decorative effect. Applied by either nailing or through use of adhesives.

Structural



WEATHERWOOD SHEATHING—2 feet x 8 feet x $2\frac{5}{32}$ inches thick, asphalt coated tongued and grooved for horizontal application, also available in 4 x 8, 4 x 9, 4 x 10 and 4 x 12 feet in either $\frac{1}{2}$ inch or $2\frac{5}{32}$ inches thickness.

WEATHERWOOD BUILDING BOARD 4 feet wide, made in lengths 6, 7, 8, 9, 10 and 12 feet, $\frac{1}{2}$ inch thick in either Ivory or Tan shades. Nailed to studs and joists, effectively insulates and decorates.

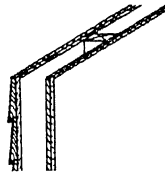
WEATHERWOOD INSULATING LATH—18 x 48 inches, with "V" edge joint. The excellent bond between the fibrous board face and the plaster eliminate necessity for plaster keys.

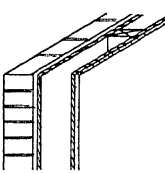
ROOF INSULATION—In sheets 22 x 47 inches: $\frac{1}{2}$, 1, $1\frac{1}{2}$ and 2 inches thick. All but the $\frac{1}{2}$ inch size are supplied laminated with either square or "ship-lapped" edges.

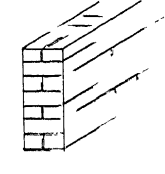
Heat Loss Factors

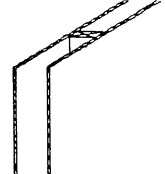
The heat loss factors shown on the opposite page indicate the comparative insulation value of various insulating treatments included in common construction systems.

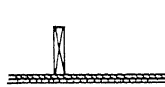
NOTE: These figures apply to 1 story buildings. To get figures for 2 story homes add 20 per cent to the values below for the wall constructions and divide by one-half for floor and ceiling constructions. It is important to use correct factor due to variations in the ratio of wall and window areas.

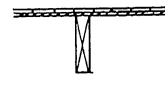
WALLS				
Basic Construction—Frame Wood Siding Wood Sheathing 2 x 4's Rocklath & Plaster				
	No Wool Between Studs	Adding Red Top Wool		
		1"	2"	3"
Basic Construction	.248	.120	.083	.064
Substituting in Above Basic Const.				
a. 2 1/2" WW Sheathing	.186	.105	.076	.059
b. 1 1/2" WW Plaster Base	.183	.103	.076	.059
c. 3/4" WW Plaster Base	.157	.094	.069	.055
d. 1" WW Plaster Base	.143	.088	.067	.054
e. 2 1/2" WW Sheathing and 1 1/2" WW Plaster Base	.147	.090	.068	.054
f. 1 1/2" WW Bldg. Bd., Tile or Plank	.187	.104	.077	.059
g. 3/4" Bldg. Bd., or Tile	.160	.095	.070	.056
h. Gyplap Sheathing	.310	.135	.090	.068
i. 1/2" Sheetrock	.260	.123	.085	.064
j. Gyplap Sheathing and 1/2" Sheetrock	.330	.136	.091	.069

WALLS				
Basic Construction—Brick Veneer 4" Brick Wood Sheathing 2 x 4's Rocklath & Plaster				
	No Wool Between Studs	Adding Red Top Wool		
		1"	2"	3"
Basic Construction	.270	.125	.085	.065
Substituting in Above Basic Const.				
a. 2 1/2" WW Sheathing	.202	.111	.078	.061
b. 1 1/2" WW Plaster Base	.200	.107	.077	.060
c. 3/4" WW Plaster Base	.178	.102	.075	.058
d. 1" WW Plaster Base	.157	.094	.070	.055
e. 2 1/2" WW Sheathing and 1 1/2" WW Plaster Base	.162	.095	.070	.055
f. 1 1/2" WW Bldg. Bd., Tile or Plank	.215	.112	.079	.061
g. 3/4" WW Bldg. Bd. or Tile	.187	.104	.075	.059
h. Gyplap Sheathing	.350	.128	.087	.066
i. 1/2" Sheetrock	.288	.130	.088	.066
j. Gyplap Sheathing and 1/2" Sheetrock	.368	.142	.093	.069

WALLS				
Basic Construction 8" Brick Wall—4" Face Brick and 4" Common Brick—No interior finish				
	No Wool Between Studs*	Adding Red Top Wool**		
		1"	2"	3"
Basic Construction	.500	.	.	.
Adding to Above Basic Const.				
a. 1/2" Plaster	.480	.	.	.
b. Rocklath and Plaster (Furred)	.300	.143	.093	.069
c. 1/2" WW Plaster Base and Pl. (Furred)	.220	.121	.084	.064
d. 3/4" WW Plaster Base and Pl. (Furred)	.190	.112	.079	.061
e. 1" WW Plaster Base and Pl. (Furred)	.160	.101	.073	.058
f. 1 1/2" WW Bldg. Bd., Tile or Plank	.230	.124	.085	.065
g. 3/4" WW Bldg. Bd., Tile or Plank	.200	.115	.081	.062
h. 1" WW Bd., Plank or Tile	.170	.104	.075	.059
i. 1/2" Sheetrock Furred	.320	.146	.095	.070
*Based on 3/8" Furring Strip **Based on Full Dimension				

WALLS				
Basic Construction—Plywood Plywood on Wood Studs 3/8" Outside—1/4" Inside with on e Air Space Over 3/4"				
	No Wool Between Studs	Adding Red Top Wool		
		1"	2"	3"
Basic Construction	.431	.151	.095	.074
Substituting in Above Basic Const.				
a. 1/2" WW Bldg. Bd., Tile or Plank	.275	.126	.087	.065
b. 3/4" WW Bldg. Bd. or Tile	.230	.115	.081	.062
c. 1" WW Bldg. Bd. or Tile	.196	.106	.076	.060
d. 3/8" Sheetrock	.430	.151	.095	.074
e. 1/2" Sheetrock	.413	.148	.095	.074
f. Adding to basic construction 2 1/2" WW Sheathing	.218	.113	.080	.061

CEILINGS				
Basic Construction 3/8" Rocklath and 1/2" Plaster				
	No Wool Between Joists	Adding Red Top Wool		
		1"	2"	3"
Basic Construction	.610	.169	.116	.080
Substituting in Above Basic Const.				
a. 1/2" WW Plaster Base & Plaster	.329	.136	.091	.068
b. 3/4" WW Plaster Base & Plaster	.290	.128	.087	.066
c. 1" WW Plaster Base & Plaster	.213	.110	.079	.061
d. 1/2" WW Bldg. Bd., Tile or Plank, No Plaster	.356	.139	.092	.067
e. 3/4" WW Bldg. Bd. or Tile	.268	.124	.086	.065
f. 1/2" WW Bldg. Bd. or Tile	.220	.113	.080	.062
g. 3/8" Sheetrock	.670	.174	.118	.089
h. 1/2" Sheetrock	.635	.170	.115	.079

FLOORS				
Basic Construction Maple or Oak Flooring on Yellow Pine Sub-Flooring				
	No Wool Between Joists	Adding Red Top Wool		
		1"	2"	3"
Basic Construction	.340	.138	.091	.068
Adding to Above Basic Const.				
a. 1/2" WW Bd. on bottom of joists	.180	.102	.075	.059
b. 3/4" WW Bd. on bottom of joists	.158	.094	.070	.055
c. 1" WW Bd. on bottom of joists	.141	.088	.066	.053

Above calculations based on data from A.S.H.V.E. GUIDE—1942.

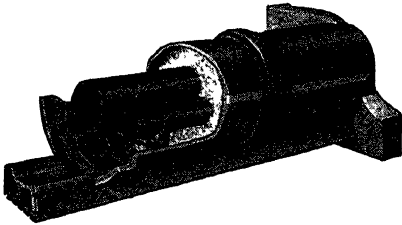
ADSCO
PRODUCTS
for STEAM
SERVICE

AMERICAN DISTRICT STEAM COMPANY

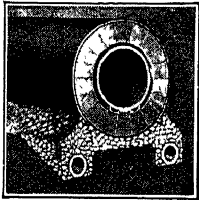
NORTH TONAWANDA, N.Y.

IN BUSINESS OVER SIXTY YEARS

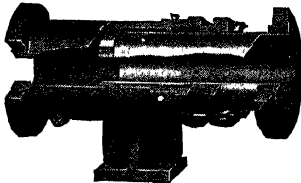
Branches and Agents in Principal Cities



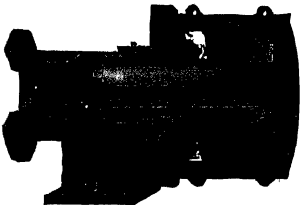
*Tile Conduit with ADSCO Filler Insulation—
a "Fiberglas" Product*



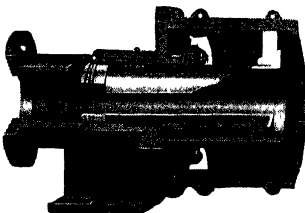
Red Diamond Brand Wood Casing



Internally Guided Joint



Internally-Externally Guided Joint



Piston-Ring Type Joint

**OVER SIXTY YEARS EXPERIENCE
IS BUILT INTO THE DESIGN AND
MANUFACTURE OF DEPENDABLE
ADSCO PRODUCTS FOR PIPE LINES**

For over sixty years ADSCO engineers have specialized in the design and application of pipe fittings and accessory equipment for underground and surface steam, water, oil and other piping systems. An extensive, modern plant including foundry, machine shop, casing mill, shipping and storage facilities enable ADSCO to produce high grade products by skilled workmen under expert supervision.

**LEADING MAKERS OF
EXPANSION JOINTS**

As pioneer manufacturers of expansion joints for pipe lines, ADSCO is the largest single producer of such equipment in the world. We offer the most extensive line of packless and slip type joints in various types to meet the requirements of any pipe line expansion and contraction problem. In addition, ADSCO produces all of the related equipment necessary to the permanent installation of efficient pipe lines, including tile conduit and wood casing for underground lines, pipe supports, saddle plates, alignment guides, steam traps, condensation and flow meters, storage and instantaneous water heaters, strainers, manhole frames, and vapor heating specialties.

ENGINEERING ASSISTANCE

ADSCO engineers welcome the opportunity of working with industrial plants, utility companies, colleges, institutions, and government departments in the solution of their pipe line expansion and contraction problems and correspondence is invited giving the details of any proposed piping installation.

WRITE FOR ADSCO CATALOG No. 35

All ADSCO products are illustrated and described in the latest ADSCO Catalog No. 35 containing over 136 pages of informative data for the specification and purchase of dependable products for underground or surface pipe line distribution systems. Write for your copy today to the American District Steam Company, 65 Bryant St., North Tonawanda, New York.

H. W. Porter & Co.

INCORPORATED

Newark, New Jersey

Permanent Protection and Insulation for Underground Pipe Lines

BALTIMORE, MD.

CHARLOTTE, N. C.

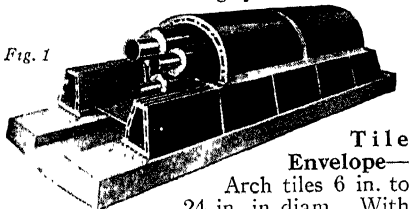
RICHMOND, VA.

Therm-O-Tile

REG. U.S. PAT. OFF.

STEAM CONDUIT SYSTEMS

For Central Heating—A complete conduit system for the permanent support, protection, and insulation of underground mains of central heating systems.



Tile
Envelope—

Arch tiles 6 in. to 24 in. in diam. With 5 different size base tiles they produce 27 different conduit cross sections.

Foundation—Base is a thick concrete slab poured directly in the trench bottom, steel reinforced when installed over filled or boggy ground. Figs. 1, 4, 6 and 7.

Drainage—Drainage is entirely internal, accurately and permanently sloped. Condensate pockets cannot form. Open to inspection at manholes. Of ample capacity to keep pipe space dry at all times. No possibility of clogging with silt or vegetation. Figs. 6 and 7.



Fig. 2—Pipe Support
for Single Pipe.

Fig. 3—Pipe Support
for Three Pipes.

Pipe Support—All pipes rest on cast-iron adjustable supports directly on base independent of tile envelope. Figs. 2, 3, 4, 6 and 7.

Accessibility—All piping is installed before tile is placed, giving complete accessibility for welding, testing and insulation. No interference of tile or other trades working in trench at same time. Pipe fitters work on convenient concrete slab "walkway." Figs. 1 and 4.

Strength—Due to immovable concrete base and arch of extra heavy tile greater loads can be carried on top of conduit without extra reinforcement.

Metal Saving—Pipe supports and saddles are the only metal used in Therm-O-Tile. Practically 100 per cent non-metallic.

Insulation—Either sectional pipe covering or Thermobestos waterproof fibre filling may be used for insulation. For single or double pipe lines, sectional insulation is recommended; for multiple pipe lines, a filler type of insulation is usually more economical. Figs. 6 and 7.

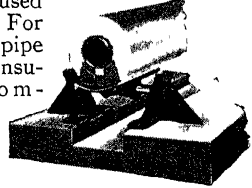


Fig. 4—Pipe Saddle. Permits full thickness of insulation between pipe and roller.

Waterproofing—Under normal soil conditions, this conduit is waterproof. If marshy or extremely wet, conduit may be completely waterproofed by use of membrane waterproofing applied under slab on sub-base and carried completely over tile envelope.

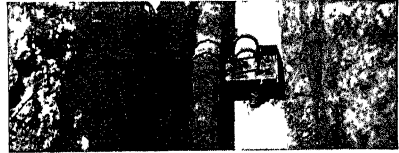


Fig. 5—Anchor Block. Fits directly in line with Base Tiles.

Efficiency—Thermal efficiency depends largely upon type and thickness of insulation used. Due to sealed air chambers in Therm-O-Tile and dry insulation space, normal efficiency of insulating material on pipe lines is increased.

Miscellaneous—Quicker installation. More easily repaired. Cave-ins and storms cause less damage and expense.

Representatives—Therm-O-Tile is sold and installed by Johns-Manville Construction Units in all principal cities.

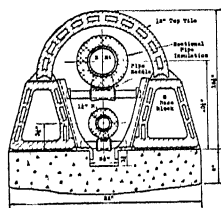


Fig. 6—Single or Double
Pipe Lines Using Sectional
Pipe Insulation.

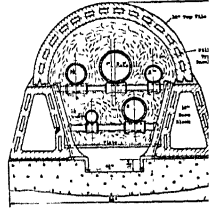


Fig. 7—Multiple Pipe
Lines Using Filler Type
Insulation.

The Ric-wiL Company

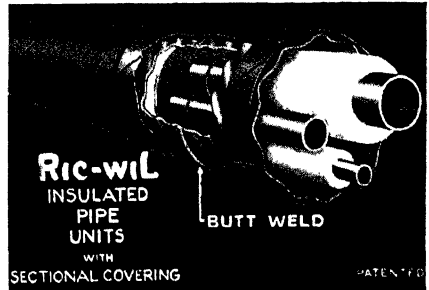
Agents in
Principal Cities

Ric-wiL

ESTABLISHED IN
1910

CONDUIT SYSTEMS FOR UNDERGROUND STEAM PIPES Union Commerce Bldg., Cleveland, Ohio

Ric-wiL Insulated Pipe Units—Pre-fabricated, pre-sealed, ready-to-install units, ideal for speed and economy. Armco Ingot Iron Conduit is coated with special asphalt $\frac{1}{8}$ in. thick over corrugations—a permanent housing for the insulated pipe which is surrounded with a protective airspace. Ample structural strength, lightweight and watertight. Furnished in any lengths, for single or multiple pipes, with any kind of steam pipe or insulation, for underground or overhead steam lines. Connections between units may be welded, as shown, or made with split conduit couplings. Write for latest Unit Bulletin.

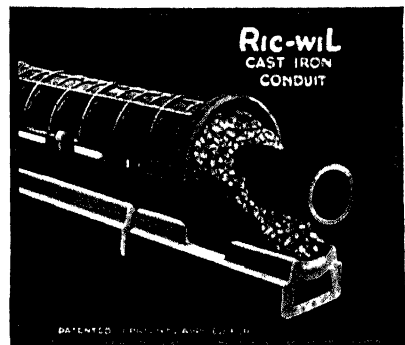
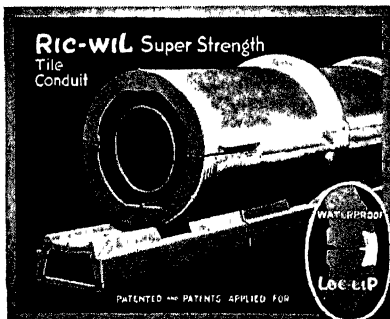


Types of Sectional Conduit—Ric-wiL SuperTile Conduit, shown below, with Dry-paC Insulation, is an extra weight, heavy duty system designed for use under highway traffic or in especially wide or deep trenches. Vitrified tile, split on the job, with Loc-liP Side Joints, interlocking construction throughout. Same design also furnished in standard weight tile (Type F). Tile is bell and spigot design, lined or unlined, and comes in 24 in. sections, 4 in. to 27 in. inside diameter. For extra heavy duty under railways, Ric-wiL is made of cast iron in 2 or 4 foot sections. Where continuous concrete base, poured on job, is desired, and reduced labor cost not essential, Ric-wiL Universal Type System is recommended. Each system supplied complete with proper pipe supports, accessories, and insulation as specified. Separate bulletin on any one of these Ric-wiL types supplied on request.

Base Drain—Standard Base Drain is vitrified salt glazed tile for tile conduit and extra heavy tile or cast iron for the cast iron conduit, in 24 in. lengths. Made in three sizes to support and drain properly all conduit sizes.

Insulation—Ric-wiL Dry-paC Waterproof Insulation is high-grade asbestos, specially processed. Any grade of commercial hand packed insulation can be furnished, also sectional pipe covering. For lined conduit, diatomaceous earth mixture is molded and keyed inside the tile.

Engineering Service—Full cooperation with architects and engineers. Installation supervision if desired. Write for Catalog Bulletin with valuable underground data.

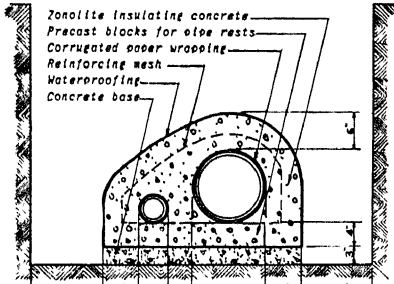


Universal Zonolite Insulation Co.

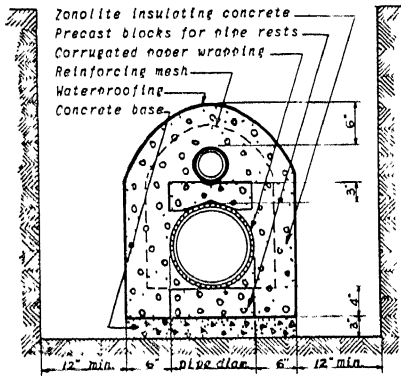
135 South LaSalle Street, Chicago, Illinois



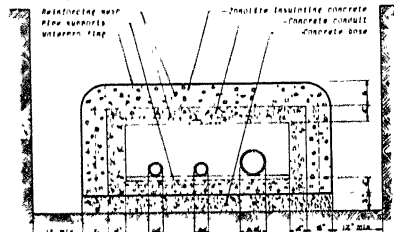
SYSTEM FOR INSULATING UNDERGROUND PIPES



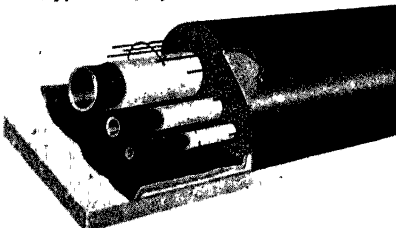
Typical straight run with pipes side by side.



Straight run with pipes one above the other.



Typical top of Zonolite construction.



Perspective of Complete System.

DESCRIPTION OF ZONOLITE SYSTEM

The Zonolite System is the modern, superior method of insulating underground pipes with Zonolite Concrete. The operations involved are as follows:

1. A structural concrete base or pad is placed in the bottom of a properly graded trench to support the pipes.
2. The base is waterproofed on top.
3. Precast Zonolite Concrete blocks are placed on the waterproofed base at intervals and the pipes are placed on them.
4. When the pipes are placed, they are wrapped with corrugated cardboard to provide a cushion for pipe expansion.
5. Reinforcing mesh is placed around the pipes, and forms are set to provide a minimum thickness of 6 inches of concrete around and over the pipes.
6. Zonolite Concrete is poured monolithically around the pipes in a continuous mass between loops or manholes.
7. When the Zonolite Concrete has set, the forms are removed and the exposed sections of concrete are waterproofed. After this, back-filling may begin.

DESCRIPTION OF ZONOLITE CONCRETE

Zonolite Insulating Concrete is formed by mixing Zonolite Concrete Aggregate with Portland cement, Zonolite Waterproofing Admix and water.

Zonolite Concrete Aggregate is made by exploding an unusual mica ore which forms a featherweight, all-mineral, inert, rotproof, fireproof, granular material with high insulating properties.

Zonolite Waterproofing Admix is a specially prepared liquid waterproofing medium which is added to Zonolite Concrete during mixing.

ADVANTAGES OF ZONOLITE SYSTEM

1. It increases efficiency by creating a continuous, unbroken covering of insulation around the pipes.
2. It forms a solid covering of water-repellent insulation eliminating joints or hollow spaces which could fill with water should the waterproofing leak.
3. It provides a permanent type insulation not subject to disintegration upon wetting, fireproof, chemically inert and rotproof.
4. It minimizes danger of damage to insulation or waterproofing due to handling.
5. It simplifies the installing and insulating of underground pipe lines.

ENGINEERING SERVICE AND SPECIFICATIONS

For engineering service and specifications write to the Universal Zonolite Insulation Co., 135 S. LaSalle Street, Chicago, Illinois.

Libbey • Owens • Ford Glass Company

Nicholas Building, Toledo, Ohio

WINDOW CONDITIONING (Storm Sash) FOR FUEL CONSERVATION

If every home in the United States was fitted with window conditioning, enough coal and fuel oil would be saved to fill a train of carriers 2,500 miles long. Every heating, ventilating and air conditioning engineer occupies a front line position in the *war on wasted fuel* for he knows the enormous savings possible with double glass insulation. By recommending storm sash and storm doors on every job, he is doing the patriotic thing and assuring greater satisfaction from equipment he specifies.

U. S. Bureau of Standards figures reveal that up to 30 per cent of a heating unit's output of warm air can be saved by window conditioning. This means a saving of three out of every ten shovelful of coal, three in every ten gallons of oil, and proportionate savings if heating is done with gas.

By letting heat escape unchecked, many home owners use much more fuel than is necessary. The savings which result through double glazing will pay for its cost in three or four years.






Storm sash, however, do more than reduce fuel consumption. They eliminate cold drafts, permit

satisfactory winter air conditioning with its higher healthful humidity, and minimize the likelihood of window fogging. The captive air space between the permanent window and the storm sash keeps the inner pane relatively warm while the outside glass is of outdoor temperature—reducing to a minimum the condensation on the inner glass.

It is possible to match practically every style of window sash without sacrificing visibility. Types range from ordinary low-cost, single pane, hook-on second sash to more elaborate ones having removable glass sections for easy cleaning inside.

This chart shows fuel savings and comparative heating costs of four types of houses, with and without window conditioning and insulation, in relatively mild, fairly severe, and cold areas.

WITH WINTER WINDOW CONDITIONING THE FIRST SMALL COST IS THE LAST . . . BUT YOU STILL SAVE FUEL YEAR AFTER YEAR

					
	Attic area ventilated above insulation Sidewalls net Window area Crack length Unheated floor	1488.5 sq. ft. 2447.7 sq. ft. 540.3 sq. ft. 590.4 lin. ft. None	770 sq. ft. 1634 sq. ft. 326 sq. ft. 389 lin. ft. None	1143 sq. ft. 1332 sq. ft. 363 sq. ft. 422 lin. ft. None	995 sq. ft. 1197.5 sq. ft. 285 sq. ft. 365 lin. ft. None
ZONE 9	HTG. COST—NO INSULATION— COAL \$10 PER TON	\$225.35	\$136.14	\$150.71	\$124.14
	Heating cost if attic is insulated	181.80	113.93	117.64	95.64
	Heating cost with window conditioning	172.32	103.25	113.93	94.21
	Savings due to insulation 3 3/8 in. minimum wool in attic floor only	43.55	19.3%	33.07	28.50
	Savings due to window conditioning only	53.03	23.5%	36.78	29.93
ZONE 7	HTG. COST—NO INSULATION— COAL \$10 PER TON	\$175.00	\$106.64	\$115.00	\$97.14
	Heating cost if attic is insulated	141.43	89.21	89.29	74.57
	Heating cost with window conditioning	133.04	80.57	87.86	74.14
	Savings due to insulation 3 3/8 in. minimum wool in attic floor only	33.57	19.2%	25.71	22.57
	Savings due to window conditioning only	41.96	24.0%	27.14	23.00
ZONE 5	HTG. COST—NO INSULATION— COAL \$10 PER TON	\$125.71	\$75.96	\$83.07	\$68.79
	Heating cost if attic is insulated	101.79	63.54	65.14	52.86
	Heating cost with window conditioning	95.89	57.71	63.14	52.61
	Savings due to insulation 3 3/8 in. minimum wool in attic floor only	23.92	19.0%	17.93	15.93
	Savings due to window conditioning only	29.82	23.7%	19.93	16.18
	Savings with both . . . TOTAL	\$ 53.74 42.7%	\$ 30.67 40.4%	\$ 37.86 46.2%	\$ 32.11 46.7%

Map above shows country divided into progressively colder zones extending from east-to-west. Savings shown in the table are for coal-burning homes in three typical zones - relatively mild, fairly severe, and extremely cold areas. Comparable savings may be obtained in homes heating with gas or oil.

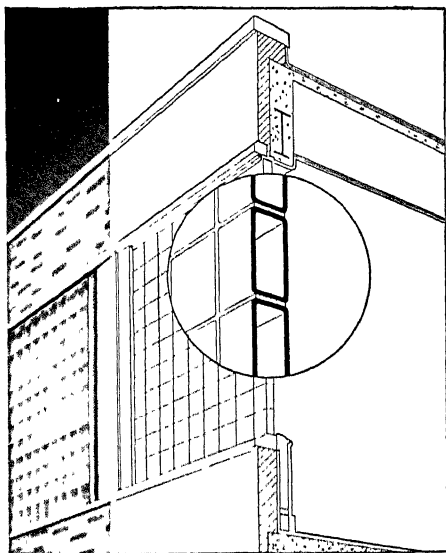
Ask your nearest Libbey • Owens • Ford distributor or dealer for complete information on window conditioning, or write direct to Libbey • Owens • Ford Glass Company, Nicholas Building, Toledo, Ohio.

OWENS-ILLINOIS
INSULUX
Glass Block

Owens-Illinois
Glass Company
INSULUX PRODUCTS DIVISION
Toledo, Ohio
Dealers in All Principal Cities

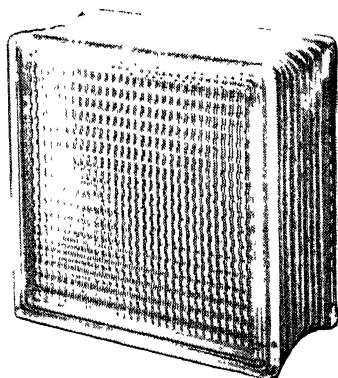
**Insulux Glass Block Give Better
Control of Interior Conditions**

Insulux Glass Block are hollow, partially evacuated block, $3\frac{3}{8}$ inches thick, with ribbed or smooth faces. Laid up in mortar in solid panels, they form a light-transmitting area that also offers high insulation value. Proper use of Insulux Glass Block results in better control of interior conditions, and therefore greater efficiency and lower initial and operating costs for cooling and heating plants.



Better Insulation

The cross-section drawing above shows why Insulux Glass Block panels give higher insulation than ordinary light-transmitting areas. The glass block, partially evacuated and with thick faces, lower the conductivity and solar heat transmission of the light-transmitting area. Air infiltration is eliminated. The better insulation provided by Insulux is a factor in planning air conditioning and heating equipment and operating costs.



Lower Heat Transmission

Tests on conductivity of Insulux Glass Block show that the heat transmission of Insulux is approximately the same as for a concrete wall 16 inches thick or a brick wall 8 inches thick. The U factor for smooth face block is .49 Btu per sq ft per hour per degree difference in temperature. For ribbed block, the U factor is .46. This test data is available for inspection by engineers.

Reduction of Solar Heat

In a comparative test of solar heat transmission, a single glazed steel sash transmitted 94 per cent more heat than an Insulux panel. As with sash, however, Insulux panels transmit less solar heat if properly oriented and well shaded. There is variation in the solar heat transmission of different designs of Insulux—data will be furnished on request.

Designs, Sizes, Erection

There are 11 designs of Insulux for both residential and industrial use. Block available in three sizes. Panels are easily and quickly erected by bricklayers. We will gladly supply any technical information and advice on installations on request.

Pittsburgh Corning Corporation

Grant Building, Pittsburgh, Pa.

Distribution through Pittsburgh Plate Glass Company warehouses in principal cities and by the W. P. Fuller Company on the West Coast.

PC Glass Blocks allow the economical use of large glass areas, reduce heat loss in cold weather and materially aid air-conditioning. This is because each PC Glass Block contains a sealed-in dead-air space that is an effective retardant to heat transfer.

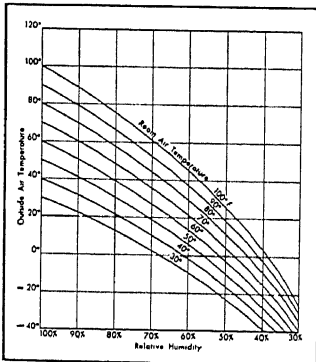
Thermal Insulation

Tests run by nationally recognized laboratories have established the value of glass blocks for insulation of light-transmitting areas. These tests have proved that with glass block panels, heat loss is slightly less than half that experienced with single-glazed windows. In computing heat losses through panels for most design purposes, it is recommended that a "U" value of 0.46 to 0.49 be used for all block sizes and face patterns. For complete data on heat transfer values see the section on heat transfer elsewhere in this Guide—page 115.

Surface Condensation

Due to high insulating value, condensation will not start forming on the room side of glass block panels until outside air has reached a temperature much lower than that necessary to produce condensation on single-glazed windows. The accompanying chart shows at what temperatures condensation will form.

Outdoor temperature required to produce condensation on the room side surface of PC Glass Block panels.



For example, with inside air at 70 F and relative humidity at 40 per cent, condensation will not begin to form on the interior surfaces of a glass block panel until an out-

door temperature of -14 deg is reached. Under similar conditions with single-glazed sash, moisture will begin to form when the outdoor temperature reaches $+33$ F.

Solar Heat Gain

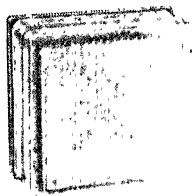
The use of glass blocks for light-transmitting areas results in a marked reduction in total solar heat gain as compared with ordinary windows. This factor is of considerable advantage in buildings that are properly air conditioned, but does not eliminate the need for adequate ventilation or shading in non-air-conditioned rooms.

For data on solar heat gain through glass blocks see the table in the solar radiation section of this Guide—page 157. This table is for standard pattern glass blocks.

PC Glass Blocks Aid Air-Conditioning

The three chief aims of air-conditioning—temperature control, humidity control and cleansing of air—are all aided by the use of PC Glass Blocks. Heat loss is less in winter—heat gain is less in summer. Ideal humidity conditions are much more easily maintained without undue condensation. Solar heat transmission and radiation are reduced. Dirt can't filter in, for each panel is a tightly sealed unit.

Sizes and Shapes Available



PC Glass Blocks are available in eight attractive patterns, some of the patterns being designed for special control and direction of transmitted daylight. For complete information on the sizes and shapes of PC Glass

Blocks, and for illustrations of the many patterns available, write the Pittsburgh Corning Corporation, Pittsburgh, Pa., or call the nearest Pittsburgh Plate Glass Company warehouse.

Additional technical data, including detailed figures on thermal insulation, solar heat gain, surface condensation, light transmission and construction data, will be furnished on request.

International Heating & Ventilating Exposition

THE AIR CONDITIONING EXPOSITION

Permanent Address—Grand Central Palace, New York, N. Y.

EXPOSITIONS HELD

The first in Philadelphia, 1930.
The second in Cleveland, 1932.
The third in New York, 1934.
The fourth in Chicago, 1936.
The fifth in New York, 1938.
The sixth in Cleveland, 1940.

The Seventh planned for Philadelphia in 1942, was postponed. The conclusion of war activities will mark the resumption of manufacture of air conditioning equipment for civilian use. At that time the Exposition will unfold tremendous opportunities for the industry and manufacturers.

These expositions have been and will be held coincident with the Annual meetings of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and are directed by the International Exposition Company, under the auspices of the A S H V E.

EXHIBITORS

Comprise leading firms in each phase of the industry; number has varied from 150 to 327 exhibitors.

EXHIBITS

These range from and comprise all the types of articles discussed or advertised in this copy of THE A.S.H.V.E. GUIDE.

1. *The COMBUSTION Group:*
Furnaces, burners (coal, oil and gas), grates, stokers, boilers, radiators (various types), refractories and auxiliaries.
2. *The OIL BURNER Group.*
3. *The HYDRAULIC Group:*
Water feeders, water heaters, pumps, traps, valves, piping, fittings, expansion joints, pipe hangers, etc.
4. *The STEAM HEATING Group:*
Vapor heating and steam specialties.
5. *The HOT WATER HEATING Group.*
6. *The AIR Group:*
Warm Air furnaces and stoves, registers and grilles, cooling towers, air filters, motors, fans, blowers, conditioning equipment, ventilators (room and industrial types), unit heaters, etc.
7. *The AIR CONDITIONING Group:*
Equipment which circulates and filters the air, in summer dehumidifies and cools; in winter heats and humidifies, and does all these in proper season for complete, all year-round air conditioning.
8. *The CONTROL Group:*
Instruments of precision for indicating, controlling or recording temperature, pressure, volume, time, flow, draft or any other function to be measured.
9. *The REFRIGERATING Group:*
Compressors, condensers, cooling apparatus, contingent apparatus and refrigerants.

10. *The CENTRAL HEATING Group:*
Apparatus and materials especially designed or adapted to the uses of central heating and central heating station supplies.
11. *The INSULATING Group:*
Structural insulators (refractory and cellulose materials), asbestos, magnesite clays and combinations thereof, pipe and conduit covering, etc., weather-stripping, etc.
12. *The MISCELLANEOUS Group:*
Electric Heaters, boiler and pipe repair alloys, liquids and compounds, tools of all kinds, and equipment not specifically included in the above groups, but related thereto.
13. *The MACHINEERY AND GENERAL EQUIPMENT Group.*
14. *BOOKS AND PUBLICATIONS*

VISITOR ATTENDANCE

Comprises a registered attendance invited to the exposition and includes:

(Figures are 1940 analysis)

INDUSTRIES

<i>Governmental</i>	401
<i>Distribution Channels</i>	
Contractors, Dealers, Jobbers, Supply Houses	7,031
<i>Home Owners</i>	333
<i>Industrial Users</i>	9,371
<i>Professional and Service Organizations</i>	689
<i>Public Utilities</i>	900
<i>Real Estate Management and Operation</i>	630
<i>Educational Institutions</i>	500
<i>Miscellaneous</i>	797
TOTAL	20,652

OCCUPATIONS

<i>Executive</i>	11,433
<i>Construction</i>	2,632
<i>Operation</i>	2,353
<i>Technical</i>	2,688
<i>Not Classified including Educators, Publishers, Home Owners, etc</i>	1,546
TOTAL	20,652

Industrial Expositions in America lead the expositions of the world in style, business effectiveness, industrial influence and educational value. This Exposition stands among the leaders in Industrial Expositions in America. It is an educational institution which brings together the research developments and improvements in equipment and materials for use in heating, ventilating and air conditioning all types of buildings.

PUBLICATIONS

●

Important to the field of heating, ventilating and air conditioning are the technical journals, trade papers and business publications serving these industries. They include regular monthly editions, special annual numbers and trade catalogs issued by commercial publishers; and many periodical and annual editions published by engineering societies and trade associations.

These publications are a year-round source of information on the many problems involved in the design, production, distribution, operation and maintenance of heating, ventilating and air conditioning equipment, and related problems in refrigeration.

In editorial content and in their advertising pages are given a comprehensive review of developments in their respective branches of the industry. By means of scientific and technical articles they disseminate information of value—they provide valuable data for the engineer, practical helps for the production man, and also serve the distributor, dealer, contractor, and the operating and maintenance man.

PUBLICATIONS (p. 1126-1135)

Specialized trade papers serving a specific branch of the industry; general publications serving the broader field of the entire industry and profession; and technical publications providing the data necessary for scientific development of the industry.

Many publications compile market statistics and provide merchandising suggestions for their readers. These services are of value not only to their readers, but are important to manufacturers who advertise their products in the pages of these publications.

Consistently read—and their contents correlated with private and governmental data on development and distribution of heating, ventilating and air conditioning equipment—these publications afford a comprehensive understanding of the problems and progress of the industry as a whole.

American Society of Refrigerating Engineers

50 West 40th Street, New York, N. Y.

REFRIGERATING ENGINEERING



The most rapidly growing magazine in the refrigeration field

REFRIGERATING ENGINEERING

REFRIGERATION and air conditioning have been found even more necessary during wartime than in times of peace—every man engaged in these industries knows of the rapid developments made during the past year.

Long acknowledged the most authoritative periodical in the field, *Refrigerating Engineering* has added steadily to the practical value of its contents, and its number of readers has grown in proportion. A wide variety of material is presented, all from the viewpoint of its usefulness to the reader in his own business. This magazine is a must for men who keep in touch with all that is new and important in refrigeration and air conditioning.

THE REFRIGERATING DATA BOOK

THE REFRIGERATING DATA BOOK is now an essential tool in the refrigeration and air conditioning industries. Editions have been published in 1932, 1934, 1936 and 1938. The 1940 Edition (Volume II) is *entirely different* from any preceding volume. It consists wholly of practical, how-it-is-done chapters on all the known applications of air conditioning and refrigeration. This *Applications Edition* carries information of a scientific and popular nature to the scores of industries using refrigeration processes.

The 1942 (Fifth Edition) of the Data Book is just off the press. This new book, replacing Volume I, has been rewritten in line with 1942 practice, and many valuable

new sections have been added to make the Data Book the most comprehensive authority available on refrigeration problems.

APPLICATION DATA BULLETINS

AN outstanding addition to REFRIGERATING ENGINEERING since 1939 is the APPLICATION DATA Bulletins which have appeared in each issue. These bulletins are also available separately at reasonable prices for single copies or quantity orders.

The APPLICATION DATA Bulletins tell precisely how refrigeration is used in various fields, giving examples and specific information on the best practice up to date. Some of the subjects covered to date are: refrigeration of locker plants, of fur storage, of restaurants, of liquids, of apples and pears, humidity in refrigeration, refrigeration service charts, refrigeration for skating rinks, butter and cheese making, milk plants, citrus fruits, beer dispensing, retail stores, wine making, load calculations, operation of ammonia machines, how to figure air conditioning, refrigeration of ships' stores, etc.

CODES AND STANDARDS

THE A.S.R.E. further contributes to refrigeration progress by its participation in establishing codes and standards in the industry. Among the recent codes made available are: No. 21—Testing and Rating Milk Coolers; No. 22—Rating and Testing Water-cooled Refrigerant Condensers (Tentative—1942); No. 23—Rating and Testing Refrigerant Compressors (Tentative—1942); No. 24—Rating and Testing Water and Brine Coolers (Tentative—1942); No. 25—Rating and Testing Forced-circulation Air Coolers for Commercial and Industrial Refrign. (Tentative—1942), (Supplement to Cir. No. 13, not sold separately.)

MEMBERSHIP ACTIVITIES

IT is the policy of the A.S.R.E. to treat in its meetings current subjects touching upon all phases of the art of refrigeration. Membership is in two grades with dues from \$10.00 to \$15.00. Sections hold meetings in the following cities: Boston, New York, Philadelphia, Detroit, Chicago, Milwaukee, St. Louis, Los Angeles, Baltimore-Washington, Richmond, Pittsburgh, Cincinnati, Cleveland, Kansas City, and Utica, N. Y. (Central New York State).

To keep apace with progress in refrigeration and air conditioning, read the publications and follow the activities of THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS, 50 West 40th St., New York, N. Y.

Coal-Heat

Published at

20 W. Jackson Blvd., Chicago, Illinois

FOR information on the sale and use of stokers, coal and coal heating equipment, you can turn to COAL-HEAT with complete confidence.

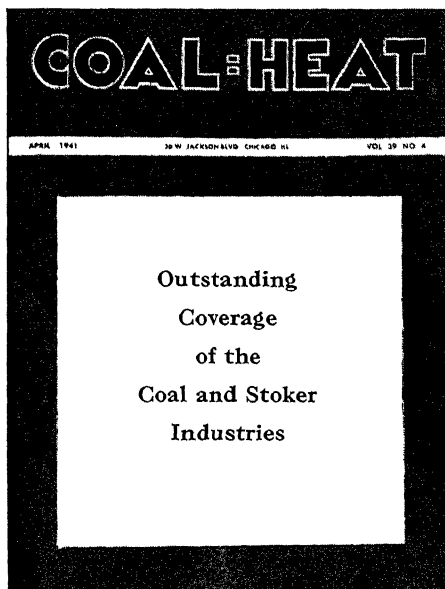
Here is a magazine that appeals to every man concerned with the use and sale of solid fuel and coal-burning equipment. Having long since recognized the extreme importance of properly designed and efficiently operated equipment to the successful use of coal, and therefore to the welfare of the coal industry,

COAL-HEAT constantly emphasizes and reiterates the significance of the "equipment factor" in solid fuel merchandising.

It is only natural that COAL-HEAT was the first trade magazine to recognize and promote the small stoker; to introduce many new developments in coal-burning equipment to the coal industry; to support the widespread use of dustless treatment in coal preparation; and to urge the sale of equipment by coal men.

COAL-HEAT has at its disposal an almost unlimited number of sources of authentic information on the topics it covers; its articles are written by the best informed men in the coal, stoker and heating industries. It enjoys quite a following, not only among the most progressive merchants in these industries, but among the industry's leading combustion and heating engineers. For years COAL-HEAT has championed the importance of the fuel engineer to the coal and stoker industries, and each year prints many articles for and by fuel engineers.

COAL-HEAT's fundamental editorial



policy is "to further the more satisfactory use and increased sale of coal and modern coal-burning equipment." Therefore it follows that COAL-HEAT actively supports the application of scientific and engineering knowledge to the burning of coal and the use of coal-burning equipment. It has directed its editorial program to both the merchandising and utilization of the coal, stoker and heating industries, believing that the two are inseparable.

With a million stokers in use today, the importance of COAL-HEAT's field is clearly evident. Each stoker installation involves both a sales and an engineering problem. It has been and is COAL-HEAT's job to supply coal and stoker men with all of the information they need to insure satisfaction for stoker users. The same is true with hand-fired heating plants and all kinds of household and commercial coal heating equipment.

In addition to providing its readers with an authentic and diversified editorial program, COAL-HEAT also publishes a number of books and booklets, manuals and reprints covering a wide range of subjects of interest to coal, stoker and heating men. Its series of heating guides for the consumer have proved particularly popular. These are available at small cost.

Subscription rates—\$2.00 a year; \$3.00 for two years. Rates apply for both United States and Canada. Foreign rates—\$2.00 a year; \$4.00 for three years.

Advertising rates and other information will be furnished upon request.

American Artisan

Published by

KEENEY PUBLISHING COMPANY

6 North Michigan Avenue, Chicago, Ill.

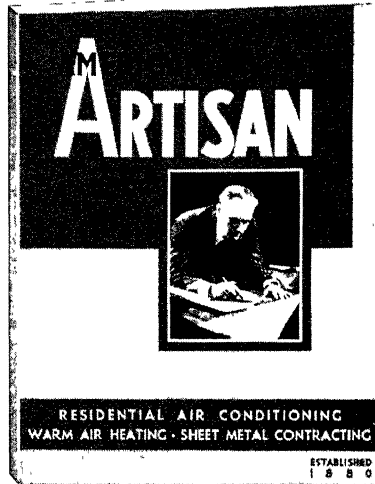
American Artisan, now in its 64th year of publication, covers the field of warm air heating, residential air conditioning, and sheet metal contracting. A special section of each issue has been devoted to air conditioning since 1932, when it first became apparent that air conditioning for homes was to be along the lines of the central, forced warm air heating system.

Its readers are warm air heating and sheet metal contractors, dealers, jobbers and manufacturers, and also architects, engineers, and public utility companies who take it for its thorough coverage of air conditioning for the home field.

To answer the industry's need for a dependable guide to equipment purchases, it publishes in each January issue a complete and up-to-the-minute directory of warm air heating, air conditioning and sheet metal products and equipment. This directory lists all products used in the field, their trade names, and the full names and addresses of all manufacturers. It is used by readers as a buying reference throughout the year.

Almost from the day interest in residential air conditioning began to develop, the advantages of the warm air type of heating system, with its duct distribution of air, were plain to see. It was adapted to all air conditioning factors, either through a self-contained central unit or through a central furnace to which could be added step-by-step or as a whole, fan, washer, humidifier, filters, controls, cooling, and automatic firing.

Today, as a result of this ready adaptability as well as economy, tens of thousands of homes have winter air conditioning—



supplied through forced warm air heating with air cleaning and humidification. Cooling apparatus can be attached to these systems readily whenever complete, year-round air conditioning is desired.

This trend in residential air conditioning has placed a premium on air handling knowledge, and has brought to the fore the one man experienced in "treating" air at a central place and getting it properly distributed—the warm air heating and sheet metal contractor.

The warm air heating industry has, furthermore, undertaken and made notable progress toward the solution of the many new engineering problems involved. All this has helped to put warm air heating in the center of residential air conditioning.

In aiding to develop this trend and assist in the solution of new problems, AMERICAN ARTISAN has provided a service to its field which has made it the recognized authority on residential air conditioning practice.

To manufacturers whose products are used in residential air conditioning, AMERICAN ARTISAN offers full coverage of the leading buying factors. Such manufacturers are invited to write for complete information about this expanding market.

AMERICAN ARTISAN is published monthly. It is a member of the Audit Bureau of Circulations and Associated Business Papers.

Subscription rates—\$2.00 per year, \$3.00 for two years in U. S., Canada, Mexico, Central and South America. Foreign \$4.00 per year.

Advertising rates furnished upon request.

Heating, Piping and Air Conditioning

Published by

KEENEY PUBLISHING COMPANY

6 North Michigan Avenue, Chicago, Ill.

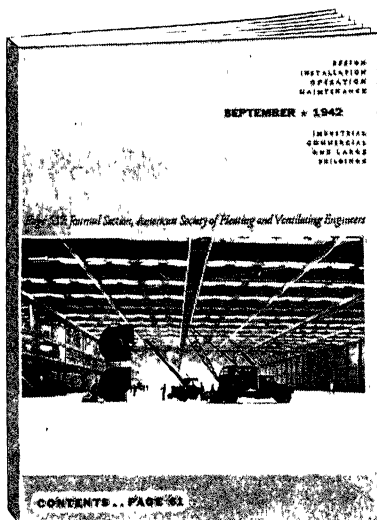
HHEATING, PIPING AND AIR CONDITIONING is the publication which carries in each issue the official JOURNAL OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS in addition to its own regular editorial section.

Its field is that of industry and large buildings. Editorially, it gives specialized attention to the design, installation, operation, and maintenance of heating, piping, and air conditioning systems in such plants and buildings.

In addition, there is published in each January issue a complete Directory of Commercial and Industrial Heating, Piping and Air Conditioning Equipment, which lists all products used in the field, their trade names, and the full names and addresses of all manufacturers. This directory has been established as the industry's buying and specifying guide, and is consulted by readers throughout the year, whenever equipment purchases are up for consideration.

H. P. & A. C. is read by consulting engineers and architects . . . contractors . . . and engineers in charge of heating, piping, and air conditioning in industrial plants, large commercial and public buildings, federal, state, and city governments, school boards and public utilities. Among its subscribers are numbered all members of the A.S.H.V.E., who represent about 30 per cent of its total circulation.

Such a coverage means, for the advertiser, consideration at all points in the selling of a heating, piping, or air conditioning product . . . consideration in the selection of a product during the preparation of plans and specifications; consideration in the actual purchase of a product for installation; consideration in



the year 'round buying of a product for operating and maintenance requirements.

It has been evident for some time that the air conditioning field is made up of two distinct markets: (1) Industrial and Commercial; (2) Residential.

These two markets are different in equipment used; different in engineering problems involved, different in engineering, distributing, and consuming personnel . . . require, therefore, different selling jobs.

To sell the industrial and large building

field for air conditioning, the manufacturer must win acceptance from the engineers who design, specify, install, operate, and select the system to meet the particular requirements of the plant or building. The system may be central, unit, or "split," but it is these engineers who are the influencing or purchasing factors.

It is to such groups that HEATING, PIPING AND AIR CONDITIONING editorially caters—exclusively in the industrial and large building field. Without waste, the manufacturer of air conditioning products and accessory equipment, such as motors, drives, controls, etc., can reach through its pages those from whom he is seeking the necessary engineering acceptance.

Manufacturers interested in this field can obtain complete information by writing to the address given above.

HEATING, PIPING AND AIR CONDITIONING is a member of the Audit Bureau of Circulations and Associated Business Papers.

Subscription rates—\$2.00 per year; \$3.00 for two years in U. S., Canada, Mexico, Central and South America. Foreign, \$4.00 per year.

Advertising rates furnished upon request

Domestic Engineering Magazine

Published Monthly by

DOMESTIC ENGINEERING PUBLICATIONS

1900 Prairie Avenue

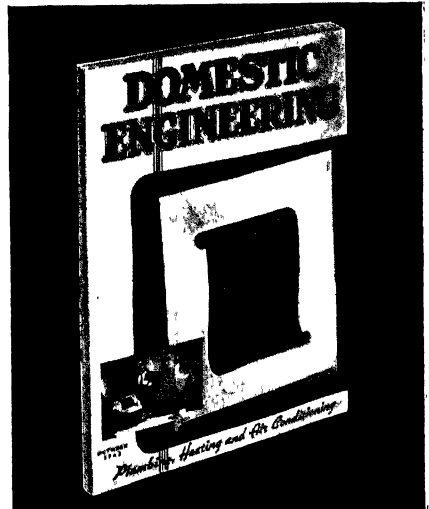


Chicago, Illinois

IN WAR As In Peace . . . the heating, plumbing and air conditioning industry has proven itself an *essential* industry. It is an industry which offers an annual market of over one billion dollars. The transition of American life, from a peace-time to a war-time basis, has found heating, plumbing and air conditioning even more essential to maximum war production than it was to the peace-time standards for which we are fighting.

The performance of the heating, plumbing and air conditioning industry during the past months stands as evidence of its vitality and its adaptability to new conditions. This performance is suggestive of the possibilities inherent in the heating, plumbing and air conditioning industry, not only for today, but in the coming post-war period.

New materials such as plastics, plywoods, and alloys, which have been developed for war; hitherto limited but common materials such as aluminum and magnesium, which will be available on a vastly expanded basis; new concepts in living standards and building construction . . . these, and other vital factors to be found in the post-war period will meet a ready application and a fertile market in



For more than 53 years, *Domestic Engineering* has served the heating and plumbing industry. The quality of this service and the leadership exhibited by *Domestic Engineering* is indicated by the award recently presented to this publication for editorial achievement in 1942. The honor was conferred in recognition of a major editorial program carried on during 1942 designed to be of maximum benefit to the industry and to the war effort under 1942 conditions.

the heating, plumbing and air conditioning industry. *Domestic Engineering Magazine* and *Domestic Engineering Catalog Directory*

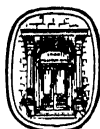
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Domestic Engineering Catalog Directory

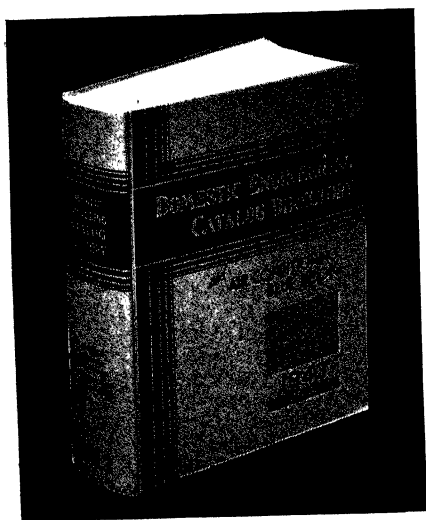
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DOMESTIC ENGINEERING PUBLICATIONS

1900 Prairie Avenue



Chicago, Illinois



In addition to its regular circulation *Domestic Engineering Catalog Directory* is distributed to War Buyers and Specifiers in Navy Yards, Ordnance Plants, Industrial Plants engaged in war and essential civilian work, Coast Guard Stations, Air Fields, Ship Yards, Cantonments, etc. Basic circulation covers the buyers and specifiers among the top ranking wholesalers, consulting engineers and contractor-dealers who have the high priorities in the heating and plumbing field.

constitute your first and most important approach to this market. These publications are not only the leading peace-time

media in this industry . . . they have maintained and increased their positions of leadership under rapidly changing war conditions.

What *Domestic Engineering Magazine* and *Domestic Engineering Catalog Directory* have done in converting to a war basis . . . that same job will be done in leading the heating, plumbing and air conditioning industry back to a sound and vital post-war program.

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For full details to assist you in your post-war planning . . . as well as to assist you under present war conditions . . . write to Domestic Engineering Co., 1900 Prairie Avenue, Chicago, Illinois.

For details of the many services available to manufacturers through *Domestic Engineering Catalog Directory*, write Manufacturers' Catalog Service Department, 1900 Prairie Avenue, Chicago, Illinois.

Fueloil & Oil Heat

232 Madison Ave.

New York, N. Y.

Lex. 2-4566-7

Los Angeles

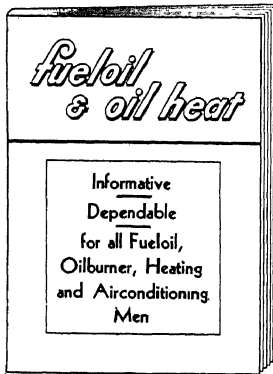
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816 W 5th St.—Mutual 8512

Baltimore

c/o FLEET-McGINLEY, INC.

Candler Bldg —Lexington 7065



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Editor

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ROBERT GRAY,
Business Manager

LEOD D. BECKER,
Chairman of Board

FUELOIL JOURNAL (20 years old) and AIR CONDITIONING & OIL HEAT (14 years old) were merged and the present paper issued commencing with the May, 1942, Number.

This move was made necessary by the War and though it entailed sacrifices, was made with the best interest of readers, advertisers, the industry generally, and the publishers, in mind.

The Oilheating Industry is surviving during Wartime due to the intelligence and hard work of its members who are doing a creditable job taking care of the heating needs of the Home Front, and producing materials of war for the Fighting Front. FUELOIL & OIL HEAT is leading the industry, attacking its problems, instructing and advising on technical matters, Governmental orders, facts and influences behind the news.

A growing list of responsible advertisers are sharing in this work; keeping their names before the field; obtaining the priorities and parts business from our readers; and co-operating with this publication in the industry's work.

Reader interest in FUELOIL & OIL HEAT is at a high level. Letters and calls pour in, on all phases of wartime operations. Responses to advertising which requests inquiries, are surprisingly high.

THE MANUFACTURERS

Most oilheating manufacturers have war-work. They had shop facilities which could be used for direct war manufacturing; or they are producing their regular equipment for military use. The extent of this military use is surprising, and is too much of a military secret to list here, but it is largely responsible for the average of 5000 oilheating units made per month and shipped by manufacturers during the last quarter of 1942.

THE DEALERS

Our surveys show that up to January, 1943, about 4000 of the original 13,000 oilheating dealers have gone out of business for any of the excellent reasons found in wartime. The remaining 9000 are the better ones, made stronger by inheriting the business volume of the departing minority. 55 per cent of these remaining have oil income to sustain them during the War; 36 per cent operate their own oil trucks; all derive income from selling service and parts to home owners.

The average oilheating user spent \$14.30 for service in 1942. Repair parts needed for each 1000 burners in operation in 1942, compared with 1941, are shown in this table:

	1941	1942
Nozzles	47	60
Strainers	19	56
Combustion chambers	27	22
Pumps	19	17
Transformers	10	17
Baffles . . .	12	13
Motors	10	13
Pressure valves	7	11
Safety controls	22	10
Pipe insulation	5	3
Circulators	7	2

When these figures are applied to the 2,386,000 burners in operation after one year of War, it is evident a sizable market for parts exists.

Installation of oil heating units during the last quarter of 1942 averaged between a high of 4000 and a low of 2400, mostly replacement sales made under P-84, by dealers, practically all from their own stocks.

For highly interesting and useful data on the Oil Heating Industry in Wartime, send \$1.00 for a copy of the January (1943) Statistical Issue (Yearbook). \$1.25 if sent C. O. D. Widely acclaimed for its accuracy.

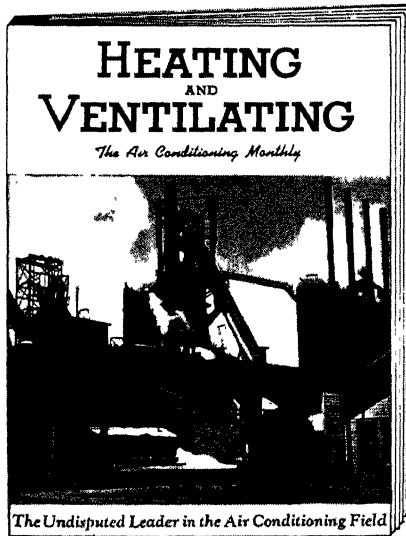
HEATING AND VENTILATING

The Air Conditioning Monthly

THE INDUSTRIAL PRESS . . . Publisher
140-148 Lafayette St. New York, N. Y.

HHEATING AND VENTILATING is edited for engineers, contractors, and equipment manufacturers who have the final word in the specification, installation, production and maintenance of mechanical equipment for heating, air conditioning and ventilating.

The editorial content is designed to be of practical use to engineers engaged in the design, installation or operating of heating, ventilating or air conditioning equipment, and is prepared under the direction of field-experienced professional engineers. A maximum amount of space is given each month to articles showing how specific problems have been met, authoritative discussions of timely sub-



jects, compilations of useful data, and descriptions of the latest practice, techniques and equipment.

Generally speaking, the emphasis is on practical rather than on technical considerations.

Each month an original Reference Data sheet is included for permanent use in a standard binder (back copies are available).

Special issues or special sections are published from time to time. A comprehensive Buyers Guide (directory of manufacturers) is published early each fall. Special

Reference Sections are published several times throughout the year on subjects of timely interest, such as Radiant Heating, Food Dehydration, Fuel Conservation, etc.

CIRCULATION

HEATING AND VENTILATING'S total distribution (May, 1942)—11,450, classified as follows:

Consulting Engineers (350) and Architects (184) Engineers Employed by them (282).....	816
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Educational Institutions, Libraries, Technical Associations.....	654
Miscellaneous and Unclassified.....	562
	10,887
Field Staff, Correspondents, Exchanges and Advertising Agencies	563
TOTAL.....	11,450
Subscriptions to HEATING AND VENTILATING are \$2.00 a year.	

Plumbing and Heating Journal

Published by

PLUMBING AND HEATING JOURNAL, INC.

45 West 45th Street, New York City

PLUMBING and Heating Journal is edited to furnish a well-rounded, efficient service to the men engaged in the plumbing, heating, ventilating and air conditioning fields. It covers both the technical and business phases of their work.

It gives free technical service through a staff of practical engineers; expert merchandising assistance, and its technical and business articles are by men of recognized competence.

Many readers come to THE JOURNAL each year for solutions to their technical problems. While some of the questions and answers are published in the Readers' Technical Service section in each issue of the magazine, the vast majority of them—having to do with practically every phase of heating, ventilating and air conditioning as well as plumbing—are answered by mail, because most of the requests for help are urgent and a delay in answering would, in some cases, entail actual monetary loss to the contractor.

The Readers' Technical Service Department of THE JOURNAL is staffed by editors who have spent their lives in the business; men who were successful plumbing, heating, ventilating and air conditioning engineers who devote their entire time to keeping abreast of the field's technical developments and using their knowledge and experience for benefit of JOURNAL subscribers.

The "Comfort Heating" department, devoted to equipment for automatic heating with coal, gas or oil, is an exclusive JOURNAL feature.

A department "With the Water Systems," informs the trade of the latest developments in the rural plumbing field and its increasing potentialities for the plumbing—heating contractor, especially with the recent extensions of rural electric lines throughout the country. Special emphasis is now also given to the necessity of increased farm production for National



Defense. Such increased production is possible, of course, largely by augmenting water systems in rural areas.

Washington Currents—THE JOURNAL, through its competent staff correspondent, Mr. Arnold Kruckman, whose headquarters are in Washington, and who is well-known among Government officials in various departments, presents in each issue first-hand story happenings of vital interest to the plumbing-heating-air

conditioning industry. Last minute news is received right up to our final press date, so as to give fresh information.

New and Improved Products—New Trade Literature—This is a regular monthly section where manufacturers' latest products and promotional material are reviewed.

Supplementing the business and technical articles and departmental material is a large amount of exclusive, staff-gathered news that highlights the background of the trade's activities.

This news background is vital. It completes the industrial picture for the reader. It keeps him in intimate touch with what the various important associations and his fellow members of the craft are doing throughout the nation and it charts the trends that are likely to have a very definite influence on the future operation of his business.

THE JOURNAL editorial department draws its news from scores of trained correspondents located at strategic points throughout the country.

This combination of the technical, business, news and other aspects of the industry enables THE JOURNAL to achieve a finely balanced magazine that gives the reader the type of information he wants and needs, in brief, compact form.

THE JOURNAL subscription price is:
1 year \$2.00, special offer, 2 years \$3.00;
3 years \$4.00.

Sheet Metal Worker

Published by Edwin A. Scott Publishing Company

45 West 45th Street

New York

THE January 1943 issue of SHEET METAL WORKER will be its Sixty-Ninth Anniversary and Directory Number. It is the oldest publication in its field and is of vital importance to men interested in sheet metal work—air conditioning—warm-air heating and ventilation. Founded and published to 1909 by David Williams Company; 1909 to 1920 by United Publishers Corp.; since 1920 by the present publisher, the Edwin A. Scott Publishing Co.

SHEET METAL WORKER is today a monthly merchandising, business and technical journal basic to the use of sheet metal. It serves the various unified merchandising and installing branches of the industry, consuming sheet metal for the erection, maintenance and operating equipment of homes and buildings, including central air conditioning equipment, warm-air heating, ventilating, dust and refuse removal, and systems for handling material by air; kitchen and restaurant work; a wide variety of interior and exterior work for commercial, industrial, institutional, and residential buildings.

Subscribers are mainly merchandising contractors purchasing practically all products and equipment which they fabricate, erect or install. Manufacturers, jobbers and distributors also subscribe

The market has three main divisions:

- (1) Equipment for resale in connection with erection or installation work.
- (2) Materials for fabrication.
- (3) Shop equipment and supplies.



CIRCULATION

SHEET METAL WORKER is a member of the Audit Bureau of Circulations and the Associated Business Papers. It has a uniform distribution, with the greater part of its circulation centered in states showing the greatest industrial activity. Readers of SHEET METAL WORKER are made up of warm-air heating, air conditioning and sheet metal contractors and dealers.

Also wholesalers, manufacturers, branch offices and salesmen. For further details send for ABC statement.

EDITORIAL

SHEET METAL WORKER has been outstanding in the editorial service it has rendered the trade and is noted for the practical usefulness of its articles and the timeliness of its editorials. Its editor is a noted author in this field and the author of several well-known books.

SHEET METAL WORKER also publishes books on heating, ventilating, sheet metal work, air conditioning, etc.

The Annual Issue published in January, contains a comprehensive and valuable Directory Section.

ADVERTISING

SHEET METAL WORKER has an enviable record of long term advertising and is proud of its long list of regular advertisers.

Because of its intimate contact with this field, SHEET METAL WORKER is well qualified to cooperate with manufacturers in their sales and advertising programs.

Subscription rates—\$2.00 per year, U.S., and Mexico. Canada \$2.50; Foreign \$3.00. Advertising rates on request.

In the Index to Modern Equipment are complete detailed listings of heating, ventilating and air conditioning equipment and materials.

Arranged alphabetically according to names of products are more than 300 items listing not only those products shown in the Catalog Data Section but also many other products made by the manufacturers represented in The Guide.

On pages 1137-1160, under each index heading—Air Cleaning Equipment, Fans, Humidifiers, Ventilators, etc.—will be found, fully cross-indexed, a complete list of manufacturers of any desired products and page numbers in the Catalog Data Section where the products are described. By reference to these index headings, the manufacturers names and the page numbers, any item of equipment or materials may be located quickly.

On page 874 are page references to the various sub-divisions of manufacturers catalog data, and on pages 875-880 will be found an alphabetical list of manufacturers whose products are shown in the Catalog Data Section.

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1943

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Corrected to January 15, 1943

Published at the Headquarters of the Society

51 Madison Avenue, New York, N. Y.

ENGINEERS OF HUMAN COMFORT

THE Heating, Ventilating and Air Conditioning Engineer through his work and research brings to our homes, our offices and our factories, in both summer and winter, that climate best suited to our comfort and health. He is truly an *Engineer of Human Comfort*.

In September 1894, a little group of engineers, educators and manufacturers gathered in New York and agreed that the great art of heating and ventilating deserved and required recognition as an essential, distinctive and highly specialized division of modern engineering. These men realized the basic importance of heating and ventilating as the primary element in the well-being of civilized mankind, living and working mostly indoors.

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51 Clafin St., Leominster

Officers and List of Chapters, 1942-43—(Continued)

Michigan

Headquarters, Detroit, Mich.

Meets: First Monday After 10th of Month

President, M. B. SHEA
8019 Jos Campau

Secretary, W. H. OLD
1761 Forest Ave., W.

Minnesota

Headquarters, Minneapolis, Minn.

Meets: First Monday in Month

President, WILLIAM McNAMARA
850 Cromwell Ave., St. Paul

Secretary, A. W. SCHULTZ
240 Seventh Ave., S., Minneapolis

Montreal

Headquarters, Montreal, Que.

Meets: Third Monday in Month

President, F. A. HAMLET
1010 St. Catherine St. W.

Secretary, A. M. DEART
637 Craig St. W.

Nebraska

Headquarters, Omaha

Meets: Second Tuesday in Month

President, H. W. STANTON
2100 Ryons St., Lincoln

Secretary, G. E. MERWIN
5012 Parker St., Omaha

New York

Headquarters, New York, N. Y.

Meets: Third Monday in Month

President, H. H. BOND
10 East 40th St.

Secretary, C. R. HIERS
19 Westminster Rd., Great Neck, L. I.

North Carolina

Headquarters, Durham, N. C.

Meets: Quarterly

President, E. R. HARDING
Box 356, Greensboro

Secretary, F. J. REED
263 College Station, Durham

North Texas

Headquarters, Dallas, Texas

Meets: Second Monday in Month

President, T. H. ANSPACHER
Tower Petroleum Bldg.

Secretary, L. C. McCLANAHAN
603 Great National Life Bldg.

Northern Ohio

Headquarters, Cleveland, Ohio

Meets: Second Monday in Month

President, C. M. H. KAERCHER
3030 Euclid Ave.

Secretary, G. B. PRIESTER
Case School of Applied Science

Oklahoma

Headquarters, Oklahoma City, Okla.

Meets: Second Monday in Month

President, E. F. DAWSON
University of Oklahoma, Norman

Secretary, E. T. P. ELLINGSON
314 Savings Bldg., Oklahoma City

Ontario

Headquarters, Toronto, Ont.

Meets: First Monday in Month

President, D. O. PRICE
131 St. Germain Ave.

Secretary, H. R. ROTH
57 Bloor St. W.

Oregon

Headquarters, Portland, Ore.

Meets: Thursday After First Tuesday in Month

President, B. W. FARNES
3019 Northeast 26th Ave.

Secretary, G. H. RISLEY
801 S. W. Stark St.

Pacific Northwest

Headquarters, Seattle, Wash.

Meets: Second Tuesday in Month

President, H. T. GRIFFITH
1411 Fourth Avenue Bldg.

Secretary, R. E. LERICHE
6345-39th, S.W., Seattle

Philadelphia

Headquarters, Philadelphia, Pa.

Meets: Second Thursday in Month

President, H. H. MATHER
611 S. Front St.

Secretary, M. G. KERSHAW
du Pont Bldg., Wilmington, Del.

Pittsburgh

Headquarters, Pittsburgh, Pa.

Meets: Second Monday in Month

President, C. M. HUMPHREYS
Carnegie Institute of Technology

Secretary, E. H. RIESMEYER, JR.
231-33 Water St.

St. Louis

Headquarters, St. Louis, Mo.

Meets: First Tuesday in Month

President, M. F. CARLOCK
7008 Amherst, University City, Mo.

Secretary, W. J. OONK
4548 Red Bud Ave., St. Louis

South Texas

Headquarters, Houston, Texas

Meets: Third Friday in Month

President, D. S. COOPER
216 E. Cowan Dr.

Secretary, A. M. CHASE, JR.
Box 359

Southern California

Headquarters, Los Angeles, Calif.

Meets: First Wednesday in Month

President, H. H. BULLOCK
212 N. Vignes St.

Secretary, LEO HUNGERFORD
4851 S. Alameda St.

Washington, D. C.

Headquarters, Washington, D. C.

Meets: Second Wednesday in Month

President, R. S. DILL
1603 S. Springwood Dr., Silver Spring, Md.

Secretary, J. W. MARKERT
8506 Garfield St., Bethesda, Md.

Western Michigan

Headquarters, Grand Rapids, Mich.

Meets: Second Monday in Month

President, F. C. WARREN
200 Division Ave. N.

Secretary, H. D. BRATT
228 Ottawa Ave. N.W.

Western New York

Headquarters, Buffalo, N. Y.

Meets: Second Monday in Month

President, H. C. SCHAFER
197 Union St., Hamburg

Secretary, HERMAN SEELBACH, JR.
45 Allen St.

Wisconsin

Headquarters, Milwaukee, Wis.

Meets: Third Monday in Month

President, H. W. SCHREIBER
507 E. Michigan St.

Secretary, I. J. HAUS
5410 W. Center St.

HOW TO APPLY FOR MEMBERSHIP

The real accomplishments of life are usually measured by the service one has rendered to his fellows and the true cultural refinement of mind, the finest sense of personal and professional ethics, factors transcending all material elements in what man calls "success," are developed through association with those of high ideals and cherished ambitions in the same field of activity. THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS offers to him whose work is definitely within its province an opportunity for such association and an opportunity for real service to his profession.

Every man in the heating, ventilating and air conditioning profession needs the Society—

- 1—Because of the contacts that it brings through national and local meetings.
- 2—Because of the information supplied by Society Publications.
- 3—Because of the opportunities that research reveals in new applications for engineering services and equipment.
- 4—Because of the satisfaction to be derived in contributing to human comfort and well being.

A Candidate must make application on the printed form "Membership Application" which is available at the headquarters office or from Chapter Officers and members. A statement of qualifications and engineering experience is required and four members must act as sponsors except under certain conditions noted in *Article B-III* of the By-Laws.

Initiation Fees for 1943 are: Members and Associate Members \$10.00; Junior Members \$5.00. The Initiation Fee must accompany application.

For 1943 the annual dues of the Society are: Members and Associate Members

\$18.00; Junior Members \$10.00; and Student Members \$3.00. Dues of new members are pro-rated on a quarterly basis.

ARTICLE C-II—MEMBERSHIP

Section 1. Persons connected with the arts and sciences related to heating, ventilating or air conditioning are eligible for admission into the Society.

Section 4. A Member shall be over thirty (30) years of age and shall have more than eight (8) years' experience in the sciences relating to the arts of heating, ventilating or air conditioning. He shall have been in active practice of his profession and in responsible charge of important work for four (4) years, consisting of design, construction, research, development or teaching, and shall be qualified to design or direct such engineering work.

Section 5. A Junior Member shall be a person over twenty (20) years and under thirty (30) years of age, who has had three (3) years experience in the sciences relating to the arts of heating, ventilating or air conditioning. Each successfully completed year in an engineering school may be considered equivalent to one (1) year of such work.

Section 6. An Associate Member shall be twenty-five (25) years of age or over. He need not be an engineer, but must have been so connected with some branch of engineering or the art of heating, ventilating, air conditioning or the industries relating thereto, that he may be considered as qualified to co-operate with heating and ventilating engineers in the advancement of professional knowledge.

Section 7. A Student Member shall be a person between the ages of 18 and 25 years, who is regularly attending courses in an engineering college or technical school at the time of applying for membership.

Roll of Membership

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

1943

(Corrected to January 15, 1943)

HONORARY MEMBERS

- BALDWIN, WM. J. (1915), New York, N. Y. (Deceased May 7, 1924).
BILLINGS, DR. J. S. (1896), New York, N. Y. (Deceased March 10, 1913.)
BOLTON, REGINALD PELHAM (1897), New York, N. Y. (Deceased February 18, 1942.)
BRECKENRIDGE, L. P. (1920), North Ferrisburg, Vt. (Deceased August 22, 1940.)
GORMLY, JOHN (Charter Member), Norristown, Pa. (Deceased January 31, 1929.)
NEWTON, C. W. (Charter Member), Baltimore, Md. (Deceased August 6, 1920.)
HOOD, O. P. (1929), Washington, D. C. (Deceased April 22, 1937.)
JELLETT, STEWART A. (Charter Member), (Presidential Member), Philadelphia, Pa. (Deceased April 5, 1935.)

LIST OF MEMBERS Arranged Alphabetically

(*Asterisk indicates authorship of papers; • indicates address for mail)

(M 1923; A 1918; J 1916) indicates, Election as Member 1923; Associate 1918; Junior 1916.
(Pres. 1923) indicates, Elected President in 1923 and is now a Presidential Member.

A

- ABBOTT, Thomas J. (M 1938) Vice-Pres., • George C. Abbott, Ltd., 119 Harbord St., and 42 Ardmore Rd., Toronto, Ont., Canada.
ABRAMS, Abraham (M 1927; J 1924) Pres., Abbey Heating Co., Inc., 81 Centre Ave., and • 100 Clove Rd., New Rochelle, N. Y.
ABRAMSON, Ralph J. (A 1938) Designer, Construction Aggregates Corp., 33 N. LaSalle St., and • 1414 Pratt Blvd., Chicago, Ill.
ACHENBACH, Paul R.* (M 1942) Asst. Mech. Engr., National Bureau of Standards, Washington, D. C., and • 1912 N. Randolph St., Arlington, Va.
ADAIR, James S. (A 1941; J 1940) Owner, • Southern Equipment Co., 205 Balter Bldg., and 520 Rue Chartres, Vieux Carre, New Orleans, La.
ADAM, Ray W. (A 1938) Owner, • W. A. Adam Co., 8810 Grinnell Ave., and 5911 Courville Ave., Detroit, Mich.
ADAMS, Bruce P. (A 1936) Gen. Mgr., • McDonnell & Miller, 400 N. Michigan Ave., Chicago, and 2211 Greenwood Ave., Wilmette, Ill.
ADAMS, Chester Z. (M 1939) Branch Mgr., • Ilg Electric Ventilating Co., 312 Piedmont Bldg., Box 1356, and 207 E. Avondale Dr., Greensboro, N. C.
ADAMS, Eugene E. (A 1938) Sales Engr., • Garden City Fan Co., 55 West 42nd St., Room 1508A, New York, and 35-46-79th St., Jackson Heights, L. I., N. Y.
ADAMS, Eugene F. (M 1941) Architectural Engr., Daly-Nixon & Adams, Archt. Engrs., 536 Insurance Bldg., and • 1227 South 52nd St., Omaha, Nebr.
ADAMS, Frank L. (M 1939) Htg.-Air Cond. Engr., • Public Service Co. of Colorado, 900-15th St., and 1185 Grape St., Denver, Colo.
ADAMS, Harold E. (M 1930) Chief Engr., • The Nash Engineering Co., Wilson Rd., South Norwalk, and Merrill Heights, Norwalk, Conn.
ADAMS, Neil D. (M 1929; A 1925; J 1922), (Council 1938-40), Supt., • Franklin Heating Station, 220 Second Ave. S.W., and 836 Eighth Ave. S.W., Rochester, Minn.
ADDAMS, Homer (Charter Member; Life Member), (Presidential Member), (Pres., 1924; 1st Vice-Pres., 1923; Treas., 1915-22; Council, 1915-25), Pres., Kewanee Boiler Co., Inc., and Fitzgibbons Boiler Co., Inc., 101 Park Ave., New York, N. Y.
ADDINGTON, Harold M. (M 1939) Wiedeman & Singleton, Greenwood, Miss.
ADDINGTON, Herbert B. (M 1938) Consulting Engr., • 13 East 37th St., New York, and 25 Lafayette Ave., Brooklyn, N. Y.
ADEMA, George E. (M 1939) Pres., • N. M. Adema & Son, 39 W. Balcom St., and 260 Warren Rd., Buffalo, N. Y.
ADLAM, T. Napier (M 1932) Vice-Pres., Sarco Manufacturing Corp., 475 Fifth Ave., New York, N. Y., and • 124 Forest Hill Rd., West Orange, N. J.
AEERLY, John J.* (M 1928), (Council, 1937-39), Chief of Div. of Htg., Vtg. & Industrial Sanitation, Chicago Board of Health, 54 W. Hubbard St., and • 6225 N. Newcastle Ave., Norwood Park, P. O., Chicago, Ill.
AHEARN, William J. (M 1929) • 791 Tremont St., Boston, and 131 Windermere Rd., Auburndale, Mass.
AHRENS, Clarence F. (A 1940) Sales Engr., R. A. Dubuque Supply Co., 3960 Duncan Ave., and • 4151 Toenges Ave., St. Louis, Mo.
AHRENS, Richard H. (A 1941) Sales Engr., Green Colonial Furnace Co., 1929 Pershing, Davenport, Iowa.

- AHLFF, Albert A.** (M 1923; A 1918) Special Repr., Marine Div., Hajoca Corp., Box 7319, Philadelphia, and •1521 Powder Mill Rd., Overbrook Park, Upper Darby, Pa.
- AINSWORTH, Samuel E.** (A 1939) Sales Engr., Roche Newton & Co., 1316 Texas Ave., and •1524-25th St., Lubbock, Texas.
- AKERS, Arthur W.** (A 1940) Dir., •Technicians Institute, 244 West 14th St., New York, N. Y., and 264 Palisade Ave., Jersey City, N. J.
- AKERS, George W.** (M 1929) Lt. Comdr., U. S. N. R., •U. S. S. Markab, c/o Fleet Post Office, San Francisco, Calif., and R. F. D. 4, Birmingham, Mich.
- ALBRIGHT, C. Barton** (A 1942; J 1938) Industrial Services Associates, Consulting Engrs., 51 East 42nd St., New York, N. Y., and •30 Normal Ave., Upper Montclair, N. J.
- ALEXANDER, Samuel W.** (M 1935) Pres.-Mgr., S. W. Alexander Co., Ltd., 182 Main St., and •124 Kingsmount Park Rd., Toronto, Ont., Canada.
- ALFERY, H. F.** (M 1938) Engr., Michael Yundt Co., 225 N. Grand Ave., Waukesha, and •1819 W. Center St., Milwaukee, Wis.
- ALGREEN, Axel B.*** (M 1930) Asst. Dist. Repr., Training within Industry, War Manpower Comm., 518 Midland Bank Bldg., and •5109 17th Ave. S., Minneapolis, Minn.
- ALLAN, William** (A 1938) Pres., •Allan Engineering Co., 724 E. Mason St., and 2735 N. Farwell Ave., Milwaukee, Wis.
- ALLEN, A. Walter** (M 1936) Sales Engr., •Pease Foundry Co., Ltd., 151 Glen Ave., Ottawa, Ont., Canada.
- ALLEN, Dewitt M.** (M 1936; J 1922) Dist. Mgr., •Ilg Electric Ventilating Co., 310 Board of Trade Bldg., Kansas City, Mo., and 3924 Cambridge, Kansas City, Kan.
- ALLEN, William A.** (A 1938) Vice-Pres., •Sprague & Sprague, Inc., 6230 Penn Ave., Pittsburgh, Pa., and 216 Highlands Ave., Ben Avon, Pa.
- ALLEN, William W.** (A 1938) Pres., American Coolair Corp., Box 2300, Jacksonville, Fla.
- ALLISON, Robert E.** (A 1941) Owner, •American Sheet Metal Co., 601 First Ave., and 7069 Fairdale, Dallas, Texas.
- ALLONIER, Howard R.** (A 1936) Dist. Mgr., •J. J. Nesbitt, Inc., 243 N. High St., Columbus, and R. D. No. 1, Powell, Ohio.
- ALLSOP, Rowland P.** (A 1940; J 1934) Consulting Engr., •1221 Bay St., and 168 Courselle Rd., Toronto, Ont., Canada.
- ALT, Harold L.*** (M 1913) Mech. Engr., Voorhees, Walker, Foley & Smith, 101 Park Ave., New York, and •115-27-225th St., St. Albans, L. I., N. Y.
- ALTEMUELLER, George F.** (A 1940) Mech. Engr. Dept. (Htg. & Refrig.), Aero Engineers, Corps of Engrs., U. S. Army, Camp Butner, and •2601 Highland Ave., Durham, N. C.
- ALVAREZ, Joaquin** (J 1942) Testing and Field Engr., Pittsburgh Lectrodryer Corp., Foot of 32nd St., and •125 Stratford Ave., East Liberty, Pittsburgh, Pa.
- AMBROSE, Alfred H.** (J 1943; S 1941) Junior Engr., Curtiss-Wright Corp., Buffalo, N. Y., and •15 River St., Woodstock, Vt.
- AMBROSE, Eugene R.** (M 1940) Air Cond. Engr., •American Gas & Electric Service Corp., 30 Church St., New York, N. Y., and 615 Springfield Ave., Cranford, N. J.
- AMMERMAN, Andrew S., Jr.** (A 1941; J 1937) Dist. Mgr., •Aerofin Corp., 411 W. Washington St., Room 558, Chicago, and 132 N. Wolf Rd., Des Plaines, Ill.
- AMMERMAN, Charles R.** (M 1916) Consulting Engr., •R. F. D. No. 1, Box 119, Wellington Villa, Alexandria, Va., and 3908 Guilford Ave., Indianapolis, Ind.
- ANDEREGG, R. H.** (M 1920) Vice-Pres. and Chief Engr., The Trane Co., and •450 Losey Court, LaCrosse, Wis.
- ANDERSON, Carl G.** (M 1942) Mech. Engr., Armour Research Foundation, 35 W. 33rd St., and •5712 W. Race Ave., Chicago, Ill.
- ANDERSON, Carroll S.** (M 1920) Mgr., American Blower Corp., 1105 Architects Bldg., Los Angeles, Calif.
- ANDERSON, David B.*** (A 1939; J 1936; S 1933) Asst. Director, Naval Training School, University Farm, and •1999 Pinehurst Ave., St. Paul, Minn.
- ANDERSON, Edwin J.** (A 1939) Mfrs. Agent, •14 Smith, and 274 Lenox, Detroit, Mich.
- ANDERSON, Edwin L.** (M 1941; J 1930) Industrial Engr., Wright Aeronautical Co., Paterson, and •63 Oakridge Rd., Verona, N. J.
- ANDERSON, Einar** (A 1940) Sales Engr., Vulcan Iron Works, Ltd., and •152 Bannerman Ave., Winnipeg, Man., Canada.
- ANDERSON, George A. M.** (A 1939; J 1936) Pres., •King Ventilating Co., and 717 S. Cedar, Owatonna, Minn.
- ANDERSON, John W.** (J 1937) Engrg. Dept., The Conditioning Co., 368 Broad St., Newark, and •621 Westminster Ave., Elizabeth, N. J.
- ANDREWS, William G.** (A 1941) Warrant Officer, Mach. A-V (S) U. S. N. R., Power Plant Superintendent, U. S. Naval Air Station, Miami, Fla.
- ANDREWS, William M.** (M 1941) Partner •Lockwood & Andrews, 904 Union National Bank Bldg., and 2254 Shakespeare, Houston, Texas.
- ANDREWS, William R.** (M 1942) Asst. Mgr., •Ross Engineering of Canada, Ltd., 920 Dominion Square Bldg., and 3770 Cote St., Catherine Rd., Montreal, Que., Canada.
- ANGERMEYER, Albert H.** (A 1936) Owner, •A. H. Angermeyer, Plumbing & Heating, 119 N. Commercial St., and 245 Webster St., Neenah, Wis.
- ANGUS, Frank M.** (M 1937) Sales Engr., Hussmann-Ligonier Co., 2401 N. Leffingwell, St. Louis, and •7428 Stanford, University City, Mo.
- ANGUS, Harry H.*** (M 1918), (Council, 1927-29), Consulting Engr., 1221 Bay St., and •34 Farnham Ave., Toronto, Ont., Canada.
- ANOFF, Seymour M.** (J 1940) Junior Mech. Engr., Army Air Corps, Materiel Div., Wright Field, and •109 Five Oaks Ave., Dayton, Ohio.
- ANSPACHER, Thomas H.** (M 1939; J 1936) Dist. Mgr., •Buffalo Forge Co., Tower Petroleum Bldg., and 4512 Arcady, Dallas, Texas.
- ANTHES, Lawrence L.** (A 1935) Pres., •Imperial Iron Corp., Ltd., 30 Jefferson Ave., and 119 Dowling Ave., Toronto, Ont., Canada.
- APT, Sanford R.** (M 1935) Mech. Engr., Parsons, Klapp, Brinkerhoff & Douglas, 142 Maiden Lane, New York, and •36-39-205th St., Bayside, L. I., N. Y.
- ARCHAMBAULT, Joseph A.** (A 1939) Branch Sales Office Mgr., •C. A. Dunham Co., Ltd., 22 Wellington St. N., Room 17, and 55A Council St., Sherbrooke, Que., Canada.
- ARCHER, David M.** (M 1934) Sales Repr., •Young Radiator Co., 143 Federal St., Boston, and 10 Harding Ave., Braintree, Mass.
- ARENBERG, Milton K.** (A 1920) Pres., •Robert Barclay, Inc., 122 N. Peoria St., Chicago, and Wildwood Lane, Highland Park, Ill.
- ARGUE, Edgar J.** (A 1935) Sales Engr., Anthes Foundry, Ltd., Saskatchewan Ave., and •773 MacMillan Ave., Winnipeg, Man., Canada.
- ARKLEY, Lorne M.** (M 1922) Retired •107 Lascells Blvd., Toronto, Ont., Canada.
- ARMBRUSTER, Frank T. W.** (M 1936) Sales Engr., American Radiator & Standard Sanitary Corp., 73 E. Naghten St., Columbus, and •105 First Ave., Waverly, Ohio.
- ARMISTEAD, William C.** (M 1937) Sales Engr., •205 Church St., Nashville, and Granny White Pike, Brentwood, Tenn.
- ARMOUR, Edson G.** (J 1940; S 1939) •Royal Canadian Air Force, No. 1 Air Navigation School, Rivers, Man., and 55 Sheridan St., Brantford, Ont., Canada.
- ARMSPACH, Otto W.*** (M 1919) Consulting Engr., 221 N. LaSalle St., Chicago, and •205 S. Summit Ave., Villa Park, Ill.

ROLL OF MEMBERSHIP

ARMSTRONG, Charles E. (M 1939) Chief Engr., •Armstrong Heat Control Co., 1626 N. E. Union Ave., and 624 N. E. Hazelfurn Ave., Portland, Ore.

ARMSTRONG, Clyde C. (A 1941) Mgr., •Commercial and Air Cond. Dept., Frigidaire Div., General Motors Sales Corp., 824 Mulberry St., and 803 Douglas Ave., Des Moines, Iowa.

ARMSTRONG, Walter J. (M 1938) Consulting Engr., •1010 St. Catherine St. W., Montreal, and 15 Willow Ave., Westmount, Que., Canada.

ARNDT, Heinrich W. (A 1935) Inspector, Plumbing and Heating, U. S. Engineering Dept., Danial Field Airbase, and •2034 Wrightsboro Rd., Augusta, Ga.

ARNOLD, Robert S. (A 1926; J 1922) Owner, Robt. Arnold Sales & Engineering Co., 409 Otis Bldg., Philadelphia, and •Haverford Mansions, Haverford, Pa.

ARONSON, Henry H. (A 1939; J 1929) Combustion Engr., Petroleum Administration for War, 624 S. Michigan Ave., and •6145 Winthrop Ave., Chicago, Ill.

ARROWSMITH, John O. (M 1934) Asst. Supt. of Works, •Canadian Kodak Co., Ltd., and 9 Humberview Rd., Toronto 9, Ont., Canada.

ARTHUR, John M., Jr. (M 1923) Div. Mgr., Lighting, Steam and Comm. Service, •Kansas City Power & Light Co., 1830 Baltimore Ave., Kansas City, Mo., and 3311 State Ave., Kansas City, Kan.

ASH, Robert S. (J 1940) Ensign, U. S. N. R., Public Works Dept., Great Lakes Naval Training Station, Great Lakes, Ill.

ASHLEY, Carlyle M.* (M 1931) Dir. of Development, •Carrier Corporation, S. Geddes St., Syracuse, and 22 Lynacres Blvd., Fayetteville, N. Y.

ASHLEY, Edward E. (M 1912) Member of Firm, •Edward E. Ashley, Consulting Engr., 10 East 40th St., New York, N. Y., and Middlesex Rd., Noroton Heights, Conn.

ATHERTON, Alfred E. (A 1937) Dir., •A. E. Atherton & Sons Pty., Ltd., 383 Latrobe St., Melbourne, and 39 Esplanade, Elwood, Victoria, Australia.

ATHERTON, George R. (M 1930) Exec. Dept., The Trane Co., LaCrosse, Wis., and •177 N. Illinois Ave., Batavia, Ill.

ATKINS, George E. (M 1941) Consulting Engr., Hobart Bldg., San Francisco, and •64 Oak Ridge Rd., Berkeley, Calif.

AUER, George G. (A 1939) Pres., •The Auer Register Co., 3608 Payne Ave., Cleveland, and 1021 Homewood Dr., Lakewood, Ohio.

AUSTIN, William H. (A 1943; J 1940; S 1937) 65 Chapman Ave., Greenwood, R. I.

AVERY, Lester T. (M 1934) Pres., Avery Engineering Co., 1906 Euclid Ave., Cleveland, and •21149 Colby Rd., Shaker Heights, Ohio

AXEMAN, James E. (M 1932; A 1931; J 1925) Gen. Sales Mgr., •Spencer Heater Div., The Aviation Corp., Box 660, and 1328 Woodmont Ave., Williamsport, Pa.

AY, Edward L. (A 1943; J 1940) Asst. Air Cond. Engr., Library of Congress, Second and Pennsylvania Ave. S.E., Washington, D. C., and •17 Mallow Hill Ave., Baltimore, Md.

B

BABCOCK, Paul R. (M 1941) Consulting Engr., G. M. Simonson, 625 Market St., San Francisco, •328-24th St., Oakland, Calif.

BABER, John E. (A 1940) Lt. U.S.N.R., U.S.S. Bainbridge, c/o Postmaster, New York, N. Y., and Charlotte, N. C.

BACHMAN, Fred (M 1936) Contractor, •Fred Bachman, 1608 N. Carlisle St., Philadelphia, and 906 Bell Ave., Yeadon, Pa.

BACHMANN, Arthur J. (J 1940; S 1939) U. S. Army, and •59-38-69th Ave., Ridgewood, L. I., N. Y.

BACHOFER, Henry A., Jr. (A 1942; J 1938) Sgt., •87th Base Hq. and Air Base Squadron, V. A. F. S. Army Air Base, Victorville, Calif., and 534 S. Eighth St., Salina, Kan.

BACKSTROM, Russell E.* (A 1931; J 1928) Mgr., •Ind. Sales Dept., Wood Conversion Co., First National Bank Bldg., and 1655 Hillcrest St., St. Paul, Minn.

BACKUS, Theodore H. L. (M 1916) Schumacher & Backus, 200-208 Hill St., and •1018 Vaughn St., Ann Arbor, Mich.

BACON, William H., Jr. (A 1942) Automotive Engr., Tide Water Associated Oil Co., Bayonne, N. J., and •149 Willow St., Brooklyn, N. Y.

BADGETT, W. Howard* (M 1937; J 1932) Major, Infantry, Post Adjutant, Camp Hood, Texas.

BADHE, Jaikrishna M. (A 1940) Asst. Engr., •Volkart Bros., Ballard Estate, Bombay, and Flat No. 11, "Palm View," Gokhale Rd., Dadar, Bombay, India.

BAECHLIN, Alfred C., Jr. (M 1942) Engr., Western Electric Co., 717 Avenue A, and •715 Avenue C, Bayonne, N. J.

BAGGALEY, Walter (M 1938) Mech. Engr., •The Austin Co., 16112 Euclid Ave., Cleveland, and 3390 Glencairn Rd., Shaker Heights, Ohio.

BAHNSON, Frederic F.* (M 1917) Consulting Engr., The Bahnsen Co., Pres., Southern Steel Stampings, Inc., and •28 Cascade Ave., Winston-Salem, N. C.

BAILEY, Albert E., Jr. (A 1938) Sales Engr., Frigidaire Div., General Motors Corp., 29 Franklin Rd., and •200 Westover Ave., Roanoke, Va.

BAILEY, Charles F. (J 1939) Newport News Shipbuilding & Drydock Co., Newport News, and •Windsor, Va.

BAILEY, Frederick A., Jr. (A 1939) Prop., •Bailey's, 130 King St., and 70 Warren St., Charleston, S. C.

BAILEY, James L. (A 1940; J 1930) Asst. Chief Engr., Parks-Cramer Co., Charlotte, N. C.

BAILEY, W. Mumford (M 1930) Managing Dir., British Trane Co., Ltd., Vectair House, Clerkenwell Close, London, E. C. 1., England.

BAIRD, Floyd E. (M 1929) Atlanta Dist. Mgr., •The Trane Co., 314 Palmer Bldg., Atlanta, and 400 Campbell Hill, Marietta, Ga.

BAKER, Donald L. (A 1940) Engr., •Martinez & Marquez (Carrier Distributors), San Juan, Puerto Rico, and 1931 Chapel St., New Haven, Conn.

BAKER, Harold S. (A 1937) Sales Engr., Bakersfield Hardware Co., 2015 Chester Ave., Bakersfield, Calif.

BAKER, Harry L., Jr. (A 1943; J 1935) Lt. (j.g.) U.S.N.R., Hollis S-10, Harvard University, Cambridge, Mass., and •948 Oakdale Rd., Atlanta, Ga.

BAKER, Irving C. (M 1921) Vice-Pres. in Charge of Sales, •Chrysler Corp., Airtemp Div., 1119 Leo St., and Box 242, Route 7, Dayton, Ohio.

BAKER, Roland H. (M 1928; A 1924) Lt. Comdr., U. S. N. R., •U. S. S. American Legion, c/o Postmaster, New York, N. Y., and Elkins, N. H.

BAKER, Thomas (M 1938) Chief Engr., Suburban Air Conditioning Corp., 10 Brookdale Pl., Mt. Vernon, and •660 East 242nd St., New York, N. Y.

BAKER, Thomas A. (M 1942) Vice-Pres., •Baker Specialty & Supply Co., 701 Erie Ave., and 2205 Broadway, Logansport, Ind.

BAKER, William H., Jr. (A 1935) Gen. Sales Dept., •American Radiator & Standard Sanitary Corp., P. O. Box 1226, and 221 Buchanan Pl., Pittsburgh, Pa.

BALDWIN, Karl F., Jr. (A 1941; J 1938) Engr., W. D. Peugh & Associates, Box 396, Pleasanton, and •1508 Arch St., Berkeley, Calif.

BALL, Frederick T. (A 1940) Mgr. Stoker-Refrigeration Appliance Dept., The Canadian Fairbanks Morse Co., Ltd., 324 Main St., and •374 Brock St., Winnipeg, Man., Canada.

BALL, William (A 1930) Pres., •Interstate Heating & Plumbing Co., 521 Southwest Blvd., Kansas City, Mo., and 1026 Shawnee Rd., Kansas City, Kan.

- BALLANTYNE, George L.** (A 1936) Royal Canadian Air Force, • Crane, Ltd., 1170 Beaver Hall Sq., and 140 Ballantyne Ave. S., Montreal W., Que., Canada.
- BALLMAN, William H.** (M 1937) Chief Engr., John A. Connelly Co., Engrs. and Contrs., 1419 N. Broad St., Philadelphia, Pa.
- BALSAM, Charles P.** (M 1932) Gen. Mgr., National Home Equipment Co., 50 Church St., New York, and • 324 Fourth St., Brooklyn, N. Y.
- BAMOND, Manuel J.** (M 1936) Sales Engineer, • Barber-Colman Co., 221 N. LaSalle St., and 5848 Kenmore Ave., Chicago, Ill.
- BANACH, Casimir J.** (J 1939) Chief Draftsman, Johnson Fan & Blower Corp., 1319 W. Lake St., and • 2346 W. Thomas St., Chicago, Ill.
- BANKS, John B.** (A 1937) North Coast Branch Mgr., • Minneapolis-Honeywell Regulator Co., 122 N. E. Broadway, and 4030 N. E. Wistaria Ave., Portland, Ore.
- BANOWSKY, Aubra B.** (M 1938) Commercial and Industrial Sales Mgr., United Gas Corp., P. O. Box 2628, and • 3735 Ingold, Houston, Texas.
- BARBIERI, Patrick J.** (A 1943; J 1936; S 1933) Air Cond. Engr., Armo Cooling & Ventilating Co., 30 West 15th St., and • 2237 Belmont Ave., New York, N. Y.
- BARNARD, M. Everett** (A 1931; J 1929) Sales Engr., • Carrier Corp., 12 South 12th St., and 380 Vernon Rd., Philadelphia, Pa.
- BARNES, Arthur F.** (M 1920) Owner, Sales Repr. and Mech. Engr., • Texas Engineering Co., 602 Kirby Bldg., and 3015 Jarrard St., Houston, Texas.
- BARNES, Arthur R.** (M 1924) Engr., • U. S. Supply Co., 1315 West 12th St., and 326 East 70th Terrace, Kansas City, Mo.
- BARNES, Hugh S.** (J 1940) Capt., • 99th C. A. (aa) A. P. O. 869, c/o Postmaster, New York, N. Y., and 2152 Sherwood Ave., Charlotte, N. C.
- BARNES, Lewis L.** (A 1942; J 1937) Air Cond. Engr., Carrier Atlanta Corp., 348 Peachtree St., and • 3995 N. Stratford Rd., Atlanta, Ga.
- BARNES, N. W.** (A 1940) Sales Repr., • The Fulton Siphon Co., 568 Wrigley Bldg., and 505 N. Michigan Blvd., Chicago, Ill.
- BARNES, Raymond W.** (M 1939) Htg., Vtg. and Air Cond. Contractor, 1208 N. Main Ave., San Antonio, Texas.
- BARNES, Walter E.** (M 1933) Pres., Barnes & Jones, Inc., 128 Brookside Ave., Jamaica Plain (Boston), and • 7 Woodlawn Ave., Wellesley Hills, Mass.
- BARNETT, Harry** (M 1942) Chief Engr., The Powers Regulator Co., 2720 Greenview Ave., Chicago, and • 923 Vernon Ave., Glencoe, Ill.
- BARNEY, William E.** (M 1936) Mgr. and Consulting Engr., • Hydraulic-Press Brick Co., Ohio and Michigan Div., South Park, and 4929 East 108th St., Cleveland, Ohio.
- BARNEY, William J.** (J 1941) Hoffman Specialty Co., 1001 York St., and • 2049 N. Meridian St., Indianapolis, Ind.
- BARNUM, Willis E., Jr.** (M 1933; J 1930) 4660 E. Marginal Way, Seattle, Wash.
- BARR, George W.** (*Life Member*; M 1905) (Board of Governors, 1910), Dist. Mgr., • Aerofin Corp., 2030 Land Title Bldg., Philadelphia, and Woods End, Villa Nova, Pa.
- BARRETT, Campbell M.** (A 1941) Canadian Active Service, and • Newton, Ont., Canada.
- BARRY, Patrick I.** (M 1920) Managing Dir., M. Barry, Ltd., • 4 Marlboro St., and 8 Sidney Park, Cork, Ireland.
- BARTELS, Charles J.** (M 1942) Owner, • Automatic Stoker & Engineering Co., 207-8 Richardson Bldg., and 1416 Washington Ave., Parkersburg, W. Va.
- BARTELS, Everett M.** (A 1941; J 1939) Mech. Engr., U. S. Army Ordnance, and • 1708 N. Quebec St., Arlington, Va.
- BARTH, Herbert E.** (M 1920) Vice-Pres., • American Blower Corp., P. O. Box 58, Roosevelt Annex, and 418 Wardell Apts., 15 E. Kirby, Detroit, Mich.
- BARTH, John W.** (A 1943; J 1939) Douglas Aircraft Corp., and • 340 Olive Ave., Long Beach, Calif.
- BARTLETT, Amos C.** (M 1919) Mgr. Htg. and Vtg. Dept., • B. F. Sturtevant Co., Hyde Park, Boston, and 22 Weston Ave., Braintree, Mass.
- BARTLETT, C. Edwin** (M 1922) Pres., • Bartlett & Co., Inc., 3112 North 17th St., and 3111 W. Coulter St., Philadelphia, Pa.
- BARTLEY, Henry E.** (M 1938) Dir. and Works Mgr., Matthews & Yates, Ltd., Cyclone Works, Swinton, and • The "Grange," Hospital Rd., Pendlebury, Lancs, England.
- BARTON, Jay** (M 1937) Owner, Barton Engineering Co., 416 Stephenson Bldg., Detroit, Mich.
- BASSETT, James W.** (A 1938) Sales Engr., • McQuay Inc., 2832 E. Grand Blvd., Detroit, and 123 Merrill St., Birmingham, Mich.
- BASTEDO, Albert E.** (M 1919) Vice-Pres., and Treas., • Burnham Boiler Corp., Irvington, and 55 Burnside Dr., Hastings-on-Hudson, N. Y.
- BASTEDO, George R.** (A 1942; J 1937) Htg. and Vtg. Engr., George A. Fuller Co. and Merritt-Chapman & Scott Corp., Quonset Point, R. I., and • 102-36-86th Rd., Richmond Hill, L. I., N. Y.
- BATES, John H.** (J 1941; S 1939) U. S. Army, and 1313 W. Lehigh, Philadelphia, Pa.
- BATTAN, Stuart W.** (M 1940) Owner, • Battan's, Avondale, and Kennett Square, Pa.
- BAUER, Albert E.** (M 1935) Chief Engr., Stainless & Steel Products Co., 1000 Berry Ave., and • 59 S. Victoria St., St. Paul, Minn.
- BAUM, Albert L.** (M 1916) Member of Firm, • Jaros, Baum & Bolles, 415 Lexington Ave., and 600 West 111th St., New York, N. Y.
- BAUMGARDNER, C. M.** (M 1928) Branch Mgr., • U. S. Radiator Corp., 3254 N. Kilbourn Ave., Chicago, and 416 Cumnor Rd., Kenilworth, Ill.
- BAXTER, Julian F.** (M 1942) Pres., • Automatic Coal Burning Corp., 499 Peachtree St., and 102 Wakefield Dr., Atlanta, Ga.
- BAXTER, Julian F., Jr.** (A 1941) Vice-Pres. and Sales Mgr., • Automatic Coal Burning Corp., 499 Peachtree St., and 197 Brighton Rd. N.E., Atlanta, Ga.
- BAXTER, William E.** (A 1939) Pres., • W. E. Baxter, Ltd., 2200 Hington Ave., Montreal, and 89-51st Ave., Lachine, Que., Canada.
- BAY, Charles H.** (A 1938) In charge of Steam Sales, • Detroit Edison Co., 2000 Second Ave., and 17323 Wildemere, Detroit, Mich.
- BAYLES, Robert W.** (A 1940) Mgr., Htg. Div., James Morrison Brass Manufacturing Co., Ltd., 276 King St. W., and • 34 Gormley Ave., Toronto, Ont., Canada.
- BAYSE, Harry V.** (*Life Member*; M 1923) Chairman of Board, • American Furnace Co., 2719-31 Delmar Blvd., and 6959 Hancock Ave., St. Louis, Mo.
- BAZZONI, Joseph P.** (A 1942) Mech. Engr., G. P. Rice Co., Keesler Field, Miss., and • Route 2, Ottawa, Ill.
- BEACH, Ralph L.** (M 1942) Branch Chief Engr., • York Ice Machinery Corp., P. O. Box 2210, and 2035 McLandon Ave. N.E., Atlanta, Ga.
- BEACH, Walter R.** (A 1936) Sales Engr., • Cleveland Electric Illuminating Co., 75 Public Sq., Cleveland, and 1185 Yellowstone Rd., Cleveland Heights, Ohio.
- BEALS, Dowell E.** (M 1941; J 1940) Gen. Mgr., Mechanical Contractors, Associated, Oklahoma Aircraft Assembly Plant Site, and • 1224 Southwest 26th St., Oklahoma City, Okla.
- BEAN, George S.** (A 1935) Mgr. Stoker Div., • North Western Fuel Co., 2196 University Ave., St. Paul, and 4949-16th Ave. S., Minneapolis, Minn.
- BEARMAN, Alexander A.** (M 1937) Engr., • 20th Century-Fox Film Corp., 444 W. 56th St., New York, and 47 Edward St., Baldwin, N. Y.
- BEATTIE, James** (A 1940) Htg. Contr., James Beattie, 17215 Greenlawn Ave., Detroit, Mich.

- BEVINGTON, Warren C.** (M 1928) Pres., •Bevington-Williams, Inc., Engineers, 730 Indiana Pythian Bldg., and 5921 Washington Blvd., Indianapolis, Ind.
- BIBER, Herbert A.** (A 1937) Engr., Mellon National Bank, 514 Smithfield St., Pittsburgh, and •323 Barnes St., Wilkinsburg, Pa.
- BIBLE, Hollis U.** (M 1940) •Taylor & Bible, Consulting Engineers, 908-10 Bankers Mortgage Bldg., and 1609 Marshall, Houston, Texas.
- BICHOWSKY, F. Russell*** (M 1935) Prof. of Chem. Engrg., •Catholic University, and 4200 13th Place N.E., Washington, D. C.
- BIGGERS, Richmond H.** (A 1939) Mfrs. Agent, •2217 E. Jefferson Ave., and 2237 E. Jefferson Ave., Detroit, Mich.
- BILLINGSLEY, Oliver F. H., II** (J 1937) •2172 West 20th St., Long Beach, and 218-39th St., Manhattan Beach, Calif.
- BINDER, Charles G.** (M 1920) Mgr., Htg. Dept., Warren Webster & Co., 17th and Federal St., Camden, and •115 Oak Terrace, Merchantville, N. J.
- BIRD, Charles** (A 1934) Treas. and Gen. Mgr., The Doermann Roehrer Co., 450 E. Pearl St., Cincinnati, Ohio.
- BIRKETT, Harold S.** (M 1940) Engr. Commercial Gas Utilization, The Brooklyn Union Gas Co., 176 Remsen St., Brooklyn, and •87 Deepwood Rd., Roslyn Heights, L. I., N. Y.
- BISHOP, Charles R.** (Life Member; M 1901) (Council, 1916) 22 Sagamore Rd., Bronxville, N. Y.
- BISHOP, Frederick R.** (M 1921) Mgr. of Sales, The Brundage Co., Kalamazoo, and •8011 Dexter Blvd., Detroit, Mich.
- BISHOP, Jacob A.** (M 1939) Dist. Mgr., •American Blower Corp., 619 Texas Bank Bldg., and 1115 N. Windomere St., Dallas, Texas.
- BISHOP, Joseph W.** (M 1939) Lt. Col., Asst. Dir. Ordnance Services, Hq., •5th Can. Armored Div., c/o Base P. O. Ottawa, and 62 Highland Crescent, R. R. No. 2, York Mills, Ont., Canada.
- BISHOP, M. W.** (M 1942; A 1939; J 1935) Branch Mgr., •American Blower Corp., Room 1011, Majestic Bldg., Milwaukee, and 4453 N. Marlborough Dr., Shorewood, Wis.
- BISPALA, John T.** (A 1940) Mgr., Bispala Bros., 2328 First Ave., Hibbing, Minn.
- BJERKEN, Maurice H.** (M 1937; A 1927) Repr., •Hoffman Specialty Co., 533 S. Seventh St., and 4952-17th Ave. S., Minneapolis, Minn.
- BLACK, Edgar N., III** (M 1922) Philadelphia Mgr., •Fitzgibbons Boiler Co., Inc., 1717 Sansom St., Philadelphia, and 111 Woodside Rd., Haverford, Pa.
- BLACK, F. C.** (Life Member; M 1919) Pres.-Treas., •F. C. Black Co., 622 W. Randolph St., and 4535 N. Ashland Ave., Chicago, Ill.
- BLACK, Harry G.** (M 1917) Prop., •P. Gormly Co., 155 N. Tenth St., and 927 North 65th St., Philadelphia, Pa.
- BLACK, James M.** (J 1940; S 1939) Sales Engr., Avery Engineering Co., 533 Mutual Home Bldg., and •605 Oakwood Ave., Dayton, Ohio.
- BLACKHALL, W. R.** (M 1922) Partner, •McKellar & Blackhall, 1104 Bay St., and 332 Waverley Rd., Toronto, Ont., Canada.
- BLACKMAN, Alfred O.** (Life Member; M 1911) •Robert & Co., Bona Allen Bldg., and 1263 Peachtree St., Atlanta, Ga.
- BLACKMORE, F. H.** (M 1923) Vice-Pres. in charge Mfg., •U. S. Radiator Corp., 1500 United Artists Bldg., Detroit, and 515 Tooting Lane, Birmingham, Mich.
- BLACKMORE, Joseph J.** (A 1939; J 1937) Mfrs. Agent, •4030 Chouteau Ave., St. Louis, Mo., and 312 S. Fillmore, Edwardsville, Ill.
- BLACKSHAW, J. L.*** (M 1937; J 1929) Engr., Air & Refrigeration Corp., 475 Fifth Ave., New York, N. Y., and •247 W. Mercer Ave., College Park, Ga.
- BLAIR, Donald W.** (A 1940) Engr., •Thomas G. Gallagher, 80 Boylston St., Boston, and 1 Chauncy St., Cambridge, Mass.
- BLAIR, Ernest L.** (M 1941) Industrial Engr., Stone & Webster Engineering Corp., 49 Federal St., Boston, and •108 Willow Ave., Wollaston (Quincy), Mass.
- BLAKELEY, Hugh J.** (M 1935) Partner, •Hubbard, Rickard & Blakeley, 275 Orange St., New Haven, and 14 Edward St., East Haven, Conn.
- BLAKER, Alfred H.** (A 1939) Secy.-Treas., •National Korectaite Co., 1619 Cortland St., and 6018 N. Francisco Ave., Chicago, Ill.
- BLANCHARD, Norris M.** (M 1942) Western Sales Mgr., •L. J. Mueller Furnace Co., 681 J. E. George Blvd., Omaha, Nebr.
- BLANDING, Robert L.** (M 1938) Vice-Pres., •Taco Heaters, Inc., 123 South St., and 1385 Smith St., Providence, R. I.
- BLANKIN, Merrill F.** (M 1927; A 1926; J 1919) (1st Vice-Pres., 1942; Treas., 1939-41; Council, 1939-42) Pres., •Haynes Selling Co., Inc., S.E. Cor. Ridge Ave. and Spring Garden St., and 528 E. Gates St., Roxboro, Philadelphia, Pa.
- BLAS, Romualdo J.** (M 1936) Mgr., Chief Engr., •Blas & Co., Apartado Postal 1006, Caracas, Venezuela, South America.
- BLAYNEY, W. Ronald** (A 1939) Secy.-Treas., W. B. Graves Heating Co., 162 N. Desplains St., and •4327 Monticello Ave., Chicago, Ill.
- BLAZER, Benjamin V.** (A 1940) Owner, •M. Blazer & Son, 173 Market St., Passaic, and 48 13th Ave., Paterson, N. J.
- BLOOM, Louis** (M 1935) Co-Partner, Freeport Plumbing and Heating Engineers, 84-A Broadway, Freeport, L. I., N. Y.
- BLUM, Herman, Jr.** (J 1936) Engr., C. Wallace Plumbing Co., Box 1209, and •4438 Emerson St., Dallas, Texas.
- BLUM, Richard J., Jr.** (A 1940) Sales Engr., •The Kirk & Blum Manufacturing Co., 2550 Spring Grove Ave., and 3909 Vine St., Cincinnati, Ohio.
- BLUMENTHAL, Moritz I.** (M 1936) Mech. Engr., U. S. Maritime Commission, Regional Construction Office, Oakland, Calif.
- BOALES, William G.** (M 1936; A 1923) Owner, •Wm. G. Boales & Associates, 8429 Hamilton Ave., Detroit, and 43 Edgemere Rd., Grosse Pointe Farms, Mich.
- BODEN, Walter F.** (A 1937) Branch Mgr., •Modine Manufacturing Co., 424 E. Wells St., Milwaukee, and 606 Milwaukee Ave., South Milwaukee, Wis.
- BODINGER, Jacob H.** (M 1931) Pres., •J. H. Bodinger Co., Inc., 530 Tenth Ave., New York, and Valley Cottage, N. Y.
- BODMER, Emmanuel** (M 1937) Address Unknown—Mail Returned.
- BOESTER, Carl F.*** (M 1939; A 1936) Dir., Housing Research, Purdue Research Foundation, Purdue University, Lafayette, Ind., and •101 E. Essex, Kirkwood, St. Louis, Mo.
- BOGATY, Hermann S.** (M 1921) 735 E. Philadelphia St., Philadelphia, Pa.
- BOLAND, L. C., Jr.** (M 1941) Consulting Engr., 774 Spring St. N.W., and •1140 Rosedale Dr. N.E., Atlanta, Ga.
- BOLAND, Roy O.** (A 1938) Mgr., Insulation Div., •Alexander Murray & Co., Ltd., 4035 Richelieu St., Montreal, and 348 Kensington Ave., Westmount, Que., Canada.
- BOND, Harry H.** (M 1938) Partner, •Edward E. Ashley, Consulting Engr., 10 East 40th St., New York, and 137-81 Belknap St., Springfield, L. I., N. Y.
- BOND, Horace A.** (M 1930) Prof. Engr., 152 Washington Ave., and •12 Ramsey Pl., Albany, N. Y.
- BONTHRON, Robert C.** (A 1935) Application Engr., Westinghouse International Co., 40 Wall St., New York, and •44 Ingraham Blvd., Hempstead, L. I., N. Y.
- BOOTH, Charles A.** (M 1917) Vice-Pres., •Buffalo Forge Co., 490 Broadway, and 142 Summit Ave., Buffalo, N. Y.
- BOOTH, Clifford A.** (A 1942) Sales Engr., •Fiber-glas Canada, Ltd., 1025 Confederation Bldg., and 4523 Kensington Ave., Montreal, Que., Canada.

ROLL OF MEMBERSHIP

- BORAK, Eugene** (M 1937) Engr., • Buensod Stacey Air Conditioning, Inc., 60 East 42nd St., New York, N. Y., and 1322 Seventh St., Port Huron, Mich.
- BORG, Elmer H.** (M 1938) Partner, • Proudfoot Rawson-Brooks & Borg, 815 Hubbell Bldg., and 3101 Easton Blvd., Des Moines, Iowa.
- BORKAT, Philip** (A 1943; J 1936) Chief Engr., Viking Air Conditioning Corp., 5600 Walworth Ave., and • 869 East 128th St., Cleveland, Ohio.
- BORNEMANN, Walter A.** (M 1924; J 1923) Sales Engr., • Carrier Corp., 12 South 12th St., Philadelphia, and 123 W. Wharton Ave., Glenside, Pa.
- BORNSTEIN, Alfred B.** (A 1942) Partner, • William Bornstein & Son, 2209 Channing St. N.E., Washington, D. C., and 7414 Piney Branch Rd., Takoma Park, Md.
- BORNSTEIN, William** (A 1937) Partner, • William Bornstein & Son, 720 New Jersey Ave. N.W., Washington, D. C., and 7414 Piney Branch Rd., Takoma Park, Md.
- BORTON, A. Robert** (A 1943; J 1939) Engrg. Dept., John J. Nesbitt, Inc., • State Rd. and Rhawn St., Philadelphia, and 3332 Decatur St., Holmesburg, Philadelphia, Pa.
- BOTELHO, Nanto J.** (A 1937) Chief Engr., and Mgr., Ceibrasil Representacoes, Ltda., Rua General Camera 64-7° Andar, Rio de Janeiro, Brazil, South America.
- BOTTOM, Edward W.** (A 1942; J 1938) Chief Engr., • Skuttle Manufacturing Co., 12989 Greeley Ave., and 13220 Woodward Ave., Detroit, Mich.
- BOUEY, Angus J.** (A 1937; J 1930) Sales Engr., • The B. F. Sturtevant Co., 681 Market St., and 4810 Fulton St., San Francisco, Calif.
- BOULLON, Lincoln** (M 1933) Consulting Engr., • Room 426, 1411 Fourth Ave. Bldg., and 3220 Sierra Dr., Seattle, Wash.
- BOWEN, Leroy F.** (A 1942) Mech. Engr., Federal Public Housing Authority, 1700 Dierks Blvd., and • 5645 Highland, Kansas City, Mo.
- BOWERMAN, E. L.** (A 1937) Flight Lt., Engr. Officer, Royal Canadian Air Force, Officers Mess, R. C. A. F., Station, Rockcliffe, Ont., and • 274 Belsize Dr., Toronto, Ont., Canada.
- BOWERS, Arthur F.** (A 1919) Pres., • Industrial Heating & Engineering Co., 828 N. Broadway, and 2853 N. Hackett Ave., Milwaukee, Wis.
- BOWLES, Porter** (A 1928) Pres., • Hoffman Specialty Co., 1001 York St., Indianapolis, and West Newton, Ind.
- BOXALL, Frederick** (M 1937) Export-Air Cond. and Refrig. Eng., Worthington Pump & Machinery Corp., Worthington Ave., Harrison, and • 86 Kenwood Ave., Verona, N. J.
- BOYAR, Sidney L.** (J 1938) Merchandise Development (Plbg. and Htg.), Sears, Roebuck & Co., Dept. 642, 925 S. Homan Ave., Chicago, Ill., and • 711 W. Chicago Ave., East Chicago, Ind.
- BOYD, Lyle E.** (A 1941) Htg. and Vtg. Engr., Remington Arms Co., Lake City Ordnance Plant, Independence, Mo., and • 5144 Roesland Lane, Kansas City, Kan.
- BOYD, Robert Lee, Jr.** (J 1941) Sales Engr., • Houston Lighting & Power Co., P. O. Box 1700, and 4017 Coleridge Ave., Houston, Texas.
- BOYD, Spencer W.** (M 1937; J 1931) Consulting Engr., • Newcomb & Boyd, 615 Trust Co. of Georgia Bldg., and 1505 Fairview Rd., Atlanta, Ga.
- BOYD, Thomas D.** (M 1937) Sales Engr., • Johnson Service Co., 1905 Dunlap St., and 3320 N. Sterling Way, Cincinnati, Ohio.
- BOYDEN, Davis S.*** (Life Member; M 1909) (Presidential Member) (Pres., 1937; 1st Vice-Pres., 1938; Treas., 1933-34; Council, 1917, 1930-38) Sr. Administration Assist. (Engr.) Signal Corps, U. S. A., 730 Commonwealth Ave., Boston, and • 1496 Commonwealth Ave., Brighton, Mass.
- BOYKER, Robert O.** (A 1942; J 1935) Contractor, • Mac Boyker & Son, 220 First Ave., and 100 Kennebeck Ave., Kent, Wash.
- BOYLE, John R.** (M 1936) Asst. Chief Engr., Westerlin & Campbell Co., 1113 Cornelia Ave., and • 6858 Osceola Ave., Chicago, Ill.
- BRAATZ, Chester J.*** (M 1930) Sales Mgr., Barber-Colman Co., and • 1819 Clinton St., Rockford, Ill.
- BRACKEN, John H.** (M 1927) Mgr., Industrial Uses Dept., • The Celotex Corp., 120 S. LaSalle St., and 455 Oakdale Ave., Chicago, Ill.
- BRADFIELD, William W.** (Life Member; M 1926) Mech. Engr., • 341 Michigan Trust Bldg., and 1352 Franklin St. S.E., Grand Rapids, Mich.
- BRADLEY, Eugene P.** (M 1906) No. 4 Yale Ave., St. Louis, Mo.
- BRANDT, Allen D.** (M 1940) P. A. Sanitary Engr., U. S. Public Health Service, Office of Chief of Ordnance, 333 N. Michigan Ave., Chicago, and • 414 Merrill Ave., Park Ridge, Ill.
- BRANDT, E. H., Jr.** (M 1928) Pres., • Reliance Engineering Co., Inc., P. O. Box 1292, and 1101 Providence Rd., Charlotte, N. C.
- BRANIFF, Paul R.** (A 1939) Secy.-Treas., • Braniff Engineering Co., 817 N. Broadway, and 2004 Northwest 16th, Oklahoma City, Okla.
- BRATT, Hero D.** (M 1937) Sales Engr., Warren Webster & Co., 228 Ottawa Ave. N.W., and • 2259 Stafford Ave. S.W., Grand Rapids, Mich.
- BRAUER, Roy** (M 1926) Dist. Mgr., • The Trane Co., Magee Bldg., and 576 Austin Ave., Mt. Lebanon, Pittsburgh, Pa.
- BRAUN, Charles R., Jr.** (J 1943; S 1939) Engr., War Dept., • Pittsburgh Ordnance Dist., Chamber of Commerce Bldg., and 4903 Forbes St., Pittsburgh, Pa.
- BRAUN, Louis T.** (M 1921) Exec. Secy., • Chicago Master Steamfitters Assn., 228 N. LaSalle St., and 1548 Pratt Blvd., Chicago, Ill.
- BRAYMAN, Albert I.** (J 1937) Mech. Designer, Jackson & Moreland, Consulting Engrs., Room 608, Park Sq. Bldg., 31 St. James Ave., Boston, and • 340 Boulevard, Revere, Mass.
- BREDESEN, Bernhard P.** (A 1931) Engr., • Reese & Bredeesen, 403 Essex Bldg., and 3623 Knox Ave. N., Minneapolis, Minn.
- BRENEMAN, Robert B.** (A 1931; J 1927) Branch Mgr., • Armstrong Cork Co., 50 E. Broad St., and 358 Arden Rd., Columbus, Ohio.
- BREWER, Frank M.** (J 1941) Associate Naval Archt., Norfolk Navy Yard, Portsmouth, and • 407 W. 30th St., Norfolk, Va.
- BREYER, Frederick** (S 1940) Student • Carnegie Institute of Technology, 5931 Walnut St., Pittsburgh, Pa., and 4219 Richton, Detroit, Mich.
- BREX, Irving E.** (A 1939) Asst. Mgr., Brex & Bieler Div., The Excelsior Steel Furnace Co., 960-60th St., and • 7200 Ridge Blvd., Brooklyn, N. Y.
- BRIDE, William T.** (M 1928; J 1925) • P. O. Box 777, Lawrence, and 28 Albion St., Methuen, Mass.
- BRIGHAM, Clare M.** (M 1935) Vice-Pres. in charge of Sales, • C. A. Dunham Co., 450 E. Ohio St., Chicago, and 420 Maple Ave., Winnetka, Ill.
- BRINKER, Harry A.** (M 1934) 2521 University, Kalamazoo, Mich.
- BRINTON, Joseph W.** (M 1920) Mgr., Boston Dist., • American Blower Corp., 1003 Statler Bldg., Boston, and 42 Gleason St., West Medford, Mass.
- BRISSENDEN, Carroll W.** (J 1939) Lt. (j.g.) U.S.N.R., and • 8443 S.W. 56th Ave., Rt. 6, Portland, Ore.
- BRISSETTE, Leo A.** (M 1930) Treas., • Trask Heating Co., 4 Merrimac St., Boston, and 168 Florence St., Melrose, Mass.
- BRITTAIN, Alfred, Jr.** (M 1938) Engr., Weather-makers (Canada), Ltd., 593 Adelaide St., and • 138 Wheeler Ave., Toronto, Ont., Canada.
- BRÖCHA, John F.** (M 1936) Buyer, Plbg. and Htg., Montgomery Ward & Co., 619 W. Chicago Ave., and • 5475 Hirsch St., Chicago, Ill.

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- BROD, Bernard M.** (J 1941) Engr., Suburban Air Conditioning Corp., 10 Brookdale Pl., and •669 N. Terrace Ave., Fleetwood, Mt. Vernon, N. Y.
- BRODERICK, Edwin L.*** (M 1933) Mech. Engr., The Engineer Board, Ft. Belvoir, and •P. O. Box 1153, Alexandria, Va.
- BRODIE, Aaron H.** (M 1942) Pres., •J. Brodie & Son, Inc., 1329 E. Fort St., and 2324 Chicago Blvd., Detroit, Mich.
- BRODNAX, George H., Jr.** (M 1938) Sales Engr., •Georgia Power Co., Electric Bldg., and 1564 Westwood Ave. S.W., Atlanta, Ga.
- BROKAW, George K.** (A 1942; J 1939; S 1938) Htg. and Vtg. Engr., U. S. Naval Supply Depot, Clearfield, and •52 Ambassador Village, Salt Lake City, Utah.
- BRONSON, Carlos E.*** (M 1919) Chief Mech. Engr., Kewanee Boiler Corp., Kewanee, Ill.
- BROOKE, Irving E.** (M 1938) Consulting Engr., •189 W. Madison St., Chicago, and 830 Keystone Ave., River Forest, Ill.
- BROOM, Benjamin A.** (M 1914) Office Engr. and Specification Writer, Gary Armor Plate Plant, Gary, Ind., and •1639 Fargo Ave., Chicago, Ill.
- BROOME, Joseph H.** (A 1936) Sales Engr., Minneapolis-Honeywell Regulator Co., 221 Fourth Ave., New York, N. Y., and •180 Walnut St., Montclair, N. J.
- BROWN, Alfred P.** (M 1927) Vice-Pres., •Reynolds Corp., 4224 S. Lowe Ave., Chicago, and 1097 Merrill St., Winnetka, Ill.
- BROWN, Aubrey I.*** (M 1923) Prof. of Htg. and Vtg., •Ohio State University, and 169 Richards Rd., Columbus, Ohio.
- BROWN, David** (M 1936) Owner, Plbg. & Htg. Business, •67 Cooper Sq., and 54 West 174th St., New York, N. Y.
- BROWN, Fosket.*** (M 1926) Pres., •Gray & Dudley Co., 222 Third Ave. N., and Hillsboro Rd., Nashville, Tenn.
- BROWN, Harper J.** (J 1940) 1st Lt., Ordnance Dept., Instructor, Gunnery, Armored Force School, Ft. Knox, Ky.
- BROWN, John S., Jr.** (J 1937) Equipment Engr., Frigidaire Div., General Motors Corp., Plant No. 2, Moraine City, and •428 Hadley Ave., Dayton, Ohio.
- BROWN, Leland S., Jr.** (S 1940) Student, Catholic University of America, and •15 Bryant St. N.W., Washington, D. C.
- BROWN, Mack D.** (M 1938; J 1936) Engr., •The Bahnsen Co., 1001 S. Marshall St., and 2914 Bon Air Ave., Winston-Salem, N. C.
- BROWN, Marvin L.** (M 1939) Vice-Pres., Dallas Air Conditioning Co., Inc., 3500 Commerce St., and •3461 Potomac St., Dallas, Texas.
- BROWN, Maurice W.** (A 1943; J 1938) Asst. Branch Mgr., •American Blower Corp., 619 Texas Bank Bldg., and 2523 W. Tenth St., Dallas, Texas.
- BROWN, Sterling D.** (J 1939) Sales Engr., Neil H. Peterson Co., 1129 Folsom St., and •235 Greenwich, San Francisco, Calif.
- BROWN, Tom** (M 1930) •Ward 24, Veterans Hospital, Dayton, Ohio, and 22151 Gratiot Ave., East Detroit, Mich.
- BROWN, William H.** (A 1923) Mgr., Brown Bros., Inc., 3015 North 22nd St., Milwaukee, Wis.
- BROWN, William L., Jr.** (A 1942) Co-Owner, Brown Bros. Plumbing & Heating Co., 1418 Woodland Dr., Durham, N. C.
- BROWN, Winfred E.** (S 1941) Student, Iowa State College, and •2026 Country Club, Ames, Iowa.
- BROWN, W. Maynard** (A 1930) Warren Webster & Co., 17th and Federal Sts., Camden, N. J.
- BROWNE, Alfred L.** (M 1923) Illinois Engineering Co., 253 Highland Rd., South Orange, N. J.
- BRUCE, Marshall** (A 1942) Asst. Secy., •George W. Akers Co., 16525 Woodward, and 4184 Bishop, Detroit, Mich.
- BRUNDAGE, F. Ward** (J 1940) 1st Lt., 0-339911, Battery E., 423rd C. A., A. P. O. 856, c/o Postmaster, New York, N. Y.
- BRUNETT, Adrian L.** (M 1923) Mech. Engr., U. S. Supervising Architects Office, Procurement Bldg., Washington, D. C., and •P. O. Box 36, Rockville, Md.
- BRUNNER, Emanuel G.** (A 1940) Burner Sales, Dome Oil Co., Inc., and •707-20th St. N.W., Washington, D. C.
- BRYAN, Wm. L., Jr.** (J 1942) Research Engr., York Ice Machinery Corp., Research Dept., and •Yorkco Club, York, Pa.
- BRYANT, Percy J.** (M 1915) Chief Engr., •Prudential Insurance Co. of America, 763 Broad St., Newark, and 754 Belvidere Ave., Westfield, N. J.
- BRYNER, John J.** (M 1942) Chief Engr., Roosevelt Hotel, 121 Baronne St., and •5701 Canal Blvd., New Orleans, La.
- BUCK, David T.** (M 1940; A 1936) Pres., •Buck Engineering Co., 37-41 Marcy St., and 116 W. Main St., Freehold, N. J.
- BUCK, Lucien** (M 1928) Engr., Proctor & Schwartz, Inc., Seventh St. and Tabor Rd., Philadelphia, and •105 Jericho Manor, Jenkintown, Pa.
- BUCKERIDGE, Victor L.** (A 1938) Owner, •H. Buckeridge & Son, 15108 Kercheval Ave., Grosse Pointe Park, and 601 Fisher Rd., Grosse Pointe, Mich.
- BUENGER, Albert*** (M 1920; J 1917) (Council, 1934-37) Bldg. Supt., Gibson Hotel, and •1204 Herschel Woods Lane, Cincinnati, Ohio.
- BUENSOD, Alfred C.** (M 1918) Pres., Buensod-Stacey Air Conditioning, Inc., 60 East 42nd St., and •33 Fifth Ave., New York, N. Y.
- BULL, Frederick W.** (M 1942) Engr., •Newcomb & Boyd, and 2554 Peachtree Rd., N.W., Atlanta, Ga.
- BULLOCK, Howard H.** (A 1933) Commercial Engr., •General Electric Co., 212 N. Vignes St., Los Angeles, and 2442 Cudahy St., Huntington Park, Calif.
- BURCH, Laurence A.** (M 1934) Sales Mgr., R. L. Deppmann Co., 5853 Hamilton Ave., Detroit, and •78 Amherst Rd., Pleasant Ridge, Royal Oak, Mich.
- BURGES, Joseph H. M.** (J 1939) Draftsman, Air & Refrigeration Corp., 475 Fifth Ave., New York, N. Y., and •20 Orchard St., Bloomfield, N. J.
- BURKE, J. J.** (M 1939; A 1937; J 1930) Engr. in charge of Air Cond. and Refrig., American Viscose Corp., Delaware Trust Bldg., Wilmington, Del.
- BURKE, John S.** (M 1942) Dealer Coordinator, •New Orleans Public Service, Inc., 317 Baronne St., and 3817 Gen. Taylor St., New Orleans, La.
- BURNAM, C. M., Jr.** (M 1938; A 1937) Editor, •Heating, Piping & Air Conditioning, 6 N. Michigan Ave., and 10565 Hale Ave., Chicago, Ill.
- BURNAP, Charles H.** (M 1941) Sales Engr., •A. K. Howell Co., 1302 Syndicate Trust Bldg., and 4987 Tholoan St., St. Louis, Mo.
- BURNETT, Earle S.** (M 1920) Senior Mech. Engr., Petroleum and Natural Gas Div., U. S. Bureau of Mines, Amarillo Helium Plant, P. O. Box 2250, and •4223 West 11th Ave., Amarillo, Texas.
- BURNS, Edward J.** (M 1923) Reuben L. Anderson, 519 Cleveland Ave. N., St. Paul, and •4716 Aldrich Ave. S., Minneapolis, Minn.
- BURNS, Frank G.** (M 1940) Major, Infantry, •U. S. Army, Staging Area No. 2, C. P. E., Charleston, S. C., and 317 Baronne St., New Orleans, La.
- BURNS, Fred C.** (M 1942; A 1919) Mgr., •Kewanee Boiler Corp., 2020 Wyandotte, and 1031 West 71st Terrace, Kansas City, Mo.
- BURNS, Harold J.** (A 1941; J 1939) Engrg. Asst., Washington Gas Light Co., 1100 H St. N.W., Washington, D. C., and •105 Allen Rd., Friendship Station, D. C.
- BURR, Griffith C.** (M 1937) Senior Mech. Engr., U. S. Engineers, Wilmington, and •823 S. Lumina Ave., Wrightsville Beach, N. C.

ROLL OF MEMBERSHIP

BURRITT, Charles G. (A 1916) Mgr., Minneapolis Office, • Johnson Service Co., 922 Second Ave. S., and Leamington Hotel, Minneapolis, Minn.

BURRITT, Edward E., Jr. (A 1941) Field Engr., General Electric Co., 1405 Locust St., and • Apt. 302, 200 W. Sedgwick St., Philadelphia, Pa.

BURTCHAEILL, James T. (A 1941) Pres., • Rushlight's, Inc., 407 S. E. Morrison St., and 2308 N.E. 31st Ave., Portland, Ore.

BURTON, W. Russell (A 1939) Sales Engr., H. J. Sandberg Co., 500 N.E. Union Ave., and • 2816 N.E. 19th St., Portland, Ore.

BUSHNELL, Carl D. (A 1921) Pres., • The Bushnell Machinery Co., 311 Ross St., Pittsburgh, and Rosslyn Farms, Carnegie, Pa.

BUSSE, Herbert (M 1936) Chief Engr., Fisher Bldg. Div., Fisher & Co., 417 Fisher Bldg., and • 16760 Greenview Rd., Detroit, Mich.

BUTLER, Peter D. (M 1922) Sales, U. S. Radiator Corp., Detroit, Mich., and • 127 Edgewater Rd., Cliffside Park, N. J.

BUTT, Roderick E. W. (A 1936; J 1930) 605 Beatty House, Dolphin Sq., London, S. W. 1, England.

BUZZARD, Francis H. (M 1939) Asst., Charles S. Leopold, Consulting Engr., 213 S. Broad St., Philadelphia, Pa., and • 624 Wood Lane, Had-donfield, N. J.

BYERS, Robert L. (M 1942) Engr., • John Paul Jones, Cary & Millar, 448 Terminal Tower Bldg., Cleveland, and 2261 Woodward Ave., Lakewood, Ohio.

YRD, T. I. (A 1936) Mgr., Bldg. Markets Dept., • The American Rolling Mill Co., and 2311 S. Sutphin St., Middletown, Ohio.

BYRNE, Joseph J. (A 1939) Htg. Engr., • Kleenair Furnace Co., 5329 N.E. Sandy Blvd., and 6416 N.E. Rodney Ave., Portland, Ore.

BYSOM, Leslie L. (M 1915) Mech. Engr., Design Section, Puget Sound Navy Yard, Public Works Dept., and • 1214 Eighth St., Bremerton, Wash.

C

CADY, Edward F. (A 1943; J 1937) Mech. Engr., The Austin Co., 16112 Euclid Ave., Cleveland, and • 2240 Rexwood Rd., Cleveland Heights, Ohio.

CAIN, William J. (S 1940) Student, 9111 Del-phine Ave., Overland, Mo.

CALDWELL, Arthur C. (M 1930) 550 South 48th St., Philadelphia, Pa.

CALDWELL, Robert J. S. (M 1941) • Carrier Engineering S. A., Ltd., Box 7821, Johannesburg, and 15 Natal St., Bellevue, Johannesburg, South Africa.

CALEB, David (M 1923) Engr., • Kansas City Power & Light Co., 1330 Baltimore Ave., and 141 Spruce St., Kansas City, Mo.

CALHOON, Floyd N. (M 1942) Asst. Prof. of Mech. Engrg., • University of Michigan, 237 W. Engineering Bldg., and 2536 W. Liberty Rd., Ann Arbor, Mich.

CALL, Joseph (M 1938; J 1936) Mgr., Air Cond. Div., Elliott-Lewis Co., 2518 N. Broad St., Philadelphia, and • 50 Fairfield Rd., Brookline Park, Delaware Co., Pa.

CALLAHAN, Peter J. (M 1934) Inspecting Engr., Central Hanover Bank & Trust Co., 60 Broadway, New York, and • 4057 Amboy Rd., Great Kills, S. I., N. Y.

CALNAN, Daniel J. (A 1942) Field Engr., Electric Furnace-Man, Inc., 101 Park Ave., New York, and • 6 Homewood Ave., Yonkers, N. Y.

CALNAN, Edward J. (M 1941) Power Engr., • The Ontario Paper Co., Ltd., Thorold, and 208 Russell Ave., St. Catharines, Ont., Canada.

CAMERON, Robert T. (J 1941; S 1938) Htg. Engr., Sanderson & Porter, Engineers & Constructors, U. S. Rubber Co. Plant, and • 917 Bromley Rd., Charlotte, N. C.

CAMPAU, W. R. (M 1940) Secy. and Gen. Mgr., • Kendall Heating Co., 1636 N.W. Lovejoy St., and 4418 Northeast 11th, Portland, Ore.

CAMPBELL, Alfred O., Jr. (A 1940, J 1933) Capt., Field Artillery, U. S. Army, and • 1678 York St., Memphis, Tenn.

CAMPBELL, Everett K.* (M 1920) (Treas. 1942; Council, 1931-33; 1939-42) Pres., • E. K. Campbell Heating Co., 2441-3-5 Charlotte St., and 3717 Harrison, Kansas City, Mo.

CAMPBELL, George S. (A 1941; J 1937) Consulting Engr., • Geo. S. Campbell, Mech. Engr., 1018 Cotton States Bldg., Nashville, and 306 Sunnyside Dr., Highland Park Station, Chattanooga, Tenn.

CAMPBELL, George W. (J 1939) Capt., Air Corps, 25th Service Group, Municipal Airport, Greenville, S. C., and • 325 A St. S.E., Washington, D. C.

CAMPBELL, Roger P. (J 1939) Secy., E. K. Campbell Heating Co., • 903 Third National Bank Bldg., and 4014 Aberdeen Rd., Nashville, Tenn.

CAMPBELL, Thomas F. (M 1928) • T. F. Campbell Co., 1013 Penn Ave., and 101 Eversia Dr., Wilksburg, Pa.

CANDEE, Bertram C. (M 1933) Partner, Beman & Candee, Consulting Engrs., 374 Delaware Ave., Buffalo, and • 19 Tremont Ave., Kenmore, N. Y.

CAPLE, Ira (J 1941; S 1938) Engr., • Super Radiator Corp., and 715 University Ave. S.E., Minneapolis, Minn.

CARBONE, James H. (M 1937) Htg. Vtg. Inspector, City of New York, Municipal Bldg., New York, and • 121-13-198th St., St. Albans, L. I., N. Y.

CAREY, Paul C. (M 1930) Member of Firm, • Runyon & Carey, Consulting Engrs., 33 Fulton St., Newark, and 31 Claremont Dr., Maplewood, N. J.

CARLE, William E. (M 1926) Pres., • Carle-Boehling Co., Inc., 1641 W. Broad St., and 4015 W. Franklin St., Richmond, Va.

CARLOCK, Marion F. (M 1936) Capt., Corps of Engineers, Office of the Area Engr., Staley Bldg., and • 802 W. Division, Decatur, Ill.

CARLSON, C. O. (A 1937) Owner, • C. O. Carlson Heating Co., 1627 Washington Ave. N., and 3528 Humboldt Ave. N., Minneapolis, Minn.

CARLSON, Everett E. (M 1932; A 1929) Branch Mgr., • The Powers Regulator Co., 2726 Locust St., and 6675 Washington Ave., St. Louis, Mo.

CARNAHAN, John H. (A 1940; J 1937) Mech. Engr., Chemical Warfare Service, • Pine Bluff Arsenal, and R. R. No. 2, Box 704, Pine Bluff, Ark.

CARON, Hector (A 1938) Mgr., Hector Caron, 324 Lincoln Highway, and • 421 S. Third St., Rochelle, Ill.

CARPENTER, Randolph H. (M 1921) (Council, 1930-35) Mgr. New York Office, • Nash Engineering Co., Graybar Bldg., 420 Lexington Ave., New York, and 20 Jefferson Ave., White Plains, N. Y.

CARRIER, Earl G. (M 1936; J 1929) Branch Mgr., Carrier Corp., 1200 Statler Bldg., Boston, and • 326 Highland Ave., Winchester, Mass.

CARRIER, Willis H.* (Life Member; M 1913) (Presidential Member) (Pres., 1931; 1st Vice-Pres., 1930; 2nd Vice-Pres., 1929; Council, 1923-32) Chairman of the Board, • Carrier Corp., 302 S. Geddes St., and 2570 Valley Dr., Syracuse, N. Y.

CARROLL, Daniel E. (A 1941) Pres., Carroll Sheet Metal Works, Inc., 46-10-70th St., and • 37-22-68th St., Woodside, L. I., N. Y.

CARROLL, Edgar E. (A 1939) Owner, • Kleenair Furnace Co., 5329 N.E. Sandy Blvd., and 2434 Northeast 43rd Ave., Portland, Ore.

CARROLL, William M. (A 1943; J 1938) Sales Engr., Pines Engineering Co., 2413 N. Pearl, and • 4108 Vincent, Dallas, Texas.

CARSON, Clifford C. (M 1930) Equipment Development & Design, U. S. Navy, Sec. 638, Bureau of Ships, Navy Dept., and • Potomac Dr., Friendship Sta., Washington, D. C.

CARTER, Alexander W. (M 1940; J 1936) • c/o Chatham Malleable & Steel Products, Ltd., 513 C. P. R. Bldg., and 117 Elmer Ave., Toronto, Ont., Canada.

- CARTER, Doctor** (M 1934) Consulting Engr., 50 Nevill Rd., Hove, Sussex, England.
- CARTER, John H.*** (M 1936) Lt., U. S. N. R., and 504 Tuxedo Blvd., Webster Groves, Mo.
- CARY, Edward B.** (M 1935) Comdr. (CEC) U. S. N. R., Public Works Officer, U. S. Naval Training Station, Great Lakes, and 1534 Henry Pl., Waukegan, Ill.
- CASE, Delbert V.** (M 1937) Engr., Edward W. Lochman P. & H. Co., 1421 Cherry St., Kansas City, and R. R. No. 1, Hickman Mills, Mo.
- CASE, Walter G.** (A 1930) Mgr., Ideal Boilers & Radiators, Ltd., Ideal House, Great Marlborough St., London, W. 1, and 66, The Ridgeway, Kenton, Harrow, Middlesex, England.
- CASEY, Byron L.** (M 1921) Mgr. Northern Dist., Ill. Electric Ventilating Co., 222 N. LaSalle St., Chicago, and 404 Vine Ave., Park Ridge, Ill.
- CASKEY, Luther H., Jr.** (J 1941; S 1938) First Lt., Co. F., 38th Engrs., A. P. O. 1257, c/o Postmaster, Miami, Fla., and 513 N. Queen St., Martinsburg, W. Va.
- CASSELL, John D.*** (Life Member; M 1913) (Council, 1930-35) Retired. 740 Garfield Ave., Palmyra, N. J.
- CASSELL, William L.** (M 1936) Principal, William L. Cassell, Mech. Engr., 912 Baltimore Ave., Kansas City, and R. F. D. No. 6, Independence, Mo.
- CHALMERS, Charles H.** (Life Member; M 1925) Gen. Mgr., Chalmers Oil Burner Co., 318 First Ave. N., and 523 Seventh St. S.E., Minneapolis, Minn.
- CHAMBERS, Fred W.** (M 1936) Pres., F. W. Chambers & Co., Ltd., 96 Bloor St. W., and 55 Glengowan Rd., Toronto, Ont., Canada.
- CHAMPLIN, Robert C.** (A 1938) Mgr., Air Cond. Engrg. Dept., Timken Silent Automatic Div., 100-400 Clark Ave., and 13640 Mendota Ave., Detroit, Mich.
- CHAPIN, C. Graham** (M 1933) Treas., Hopson & Chapin Manufacturing Co., 231 State St., and 66 Faure Harbor Pl., New London, Conn.
- CHAPIN, Harvey G.** (M 1935) 1st Lt., U. S. Army Air Corps., 8505 Warren Ave., Detroit, Mich., and 8352 Maryland Ave., Chicago, Ill.
- CHAPMAN, D. Bascom** (M 1941) Dist. Office Mgr., Clarage Fan Co., 323 Curtis Bldg., 2842 W. Grand Blvd., Detroit, Mich.
- CHAPMAN, William A., Jr.** (M 1936) Lt., U. S. N. R., c/o Navy Recruiting Station, Phoenix, Ariz., and 574 Daytona Pkwy., Dayton, Ohio.
- CHAPPELL, Henry D.** (M 1931) Mech. and Elec. Engr., Burroughs Adding Machine Co., 6071 Second Blvd., and 15493 Whitcomb Ave., Detroit, Mich.
- CHARLES, Paul L.** (M 1938) Mgr. and Sole Owner, Walsh & Charles, Ltd., 206 Tribune Bldg., and 145 Ash St., Winnipeg, Man., Canada.
- CHASE, Arthur M., Jr.** (M 1938) Sales Engr., York Ice Machinery Corp., Box 359, 2201 Texas Ave., and 3333 Ozark St., Houston, Texas.
- CHASE, Chauncey L.** (M 1931) 222 Chapel Rd., Manhasset, L. I., N. Y.
- CHASE, L. Richard** (M 1938; J 1931) Coordinator, Johnson & Johnson, 4949 West 65th St., Chicago, and 420 Leonard, Park Ridge, Ill.
- CHASE, Peter S.** (A 1940) Owner, Chase Co., 936 Oak St., and 1167 Ferry St., Eugene, Ore.
- CHASE, Roger E.** (A 1939) Pres., R. E. Chase & Co., Inc., Tacoma Bldg., and 117 N. Tacoma Ave., Tacoma, Wash.
- CHASE, Roger E., Jr.** (J 1941) Private, 417 Ordnance Dept. A. V. N., Geiger Field, Spokane, Wash., and 831 S.W. Sixth Ave., Portland, Ore.
- CHESEMAN, Evans W.** (J 1937; S 1934) Capt., Personnel Officer, Engr. Hq. 1004th Communication Zone Section, Camp Claiborne, La., and 1503 Willow St., Coffeyville, Kan.
- CHENEVERT, J. Georges** (M 1938) Consulting Engr., Arthur Surveyer & Co., Room 1203, 1010 St. Catherine St. W., Montreal, and 536 Outremont, Que., Canada.
- CHERNE, Realto E.** (M 1938; J 1929) Branch Mgr., Carrier Corp., 1235 Carew Tower, Cincinnati, and 1 Albert Pl., Station M., Mariemont, Ohio.
- CHERRY, Lester A.*** (M 1921) Consulting Engr., Cherry, Cushing and Preble, Consulting Engrs., 271 Delaware Ave., Buffalo, and 151 Euclid Ave., Kenmore, N. Y.
- CHESTER, Frank L.*** (A 1940) Mgr., W. G. Chester & Son, 179 Bannatyne Ave., and 219 Kingston Row, Winnipeg, Man., Canada.
- CHESTER, Thomas*** (M 1917) Consulting Engr., Newcomb-Detroit Co., 5741 Russell St., and 700 Seward Ave., Detroit, Mich.
- CHEYNEY, Charles C.** (A 1913) Asst. Sales Mgr., Buffalo Forge Co., 490 Broadway, and 255 Lincoln Pkwy., Buffalo, N. Y.
- CHILDS, Lewis A.** (M 1938) Dist. Sales Mgr., Clarage Fan Co., 520 Commercial Trust Bldg., Philadelphia, and 330 Harrison Ave., Glenside, Pa.
- CHRISTENSON, Harry** (A 1931) Co-Partner, Hunter-Prell Co., 15-19 E. Jackson St., and 121 Sunset Blvd., Battle Creek, Mich.
- CHRISTIERSON, Carl A.** (A 1939; J 1937) Mgr., Carrier Engineering S. A., Ltd., Box 2421, and 407 Buckingham Court, 91 Smith St., Durban, South Africa.
- CHRISTMANN, William F.** (A 1931) Engr., Kroeschell Engineering Co., 215 W. Ontario St., and 6551 N. Maplewood Ave., Chicago, Ill.
- CHRISTOPHERSEN, Andrew E.** (M 1935) Board of Education, Spalding School, 1628 Washington Blvd., and 2923 N. Kilpatrick Ave., Chicago, Ill.
- CHURCH, H. J.** (M 1922) Mgr., Darling Brothers, Ltd., 137 Wellington St. W., Toronto, and 358 Main St. N., Weston, Ont., Canada.
- CLAPPERTON, Robert** (J 1942) Engr., Canadian Industries, Ltd., 1155 Beaver Hall Sq., Montreal, and 1070 Laird Blvd., Town of Mt. Royal, Que., Canada.
- CLARE, Fulton W.** (M 1927) 935 Plymouth Rd. N.E., Atlanta, Ga.
- CLARK, Albert C.** (A 1939) Capt., U. S. Army, A. P. O. 947, Seattle, Wash.
- CLARK, Allan M.** (J 1942) Sales Engr., Canadian Blower & Forge Co., Ltd., Room 301, 1221 Bay St., Toronto, and 11 Langton Ave., Toronto (12), Ont., Canada.
- CLARK, E. Harold** (M 1922) Mfrs. Agent, 600 Michigan Theatre Bldg., and 2539 Lakewood, Detroit, Mich.
- CLARK, James R.** (J 1942) Pvt., U. S. Army, Air Depot Supply Sqdn., A. P. O. 695, c/o Postmaster, New York, and 1501 Pecan Ave., Charlotte, N. C.
- CLARK, Lynn W.** (A 1938) Engr. and Salesman, Hall-Neal Furnace Co., 1324 N. Capitol Ave., and 737 West 32nd St., Indianapolis, Ind.
- CLARK, Robert L.** (A 1918) Pres., The Clark Asbestos Co., 1893 East 55th St., Cleveland, and 927 Caledonia Ave., Cleveland Heights, Ohio.
- CLARKE, John H.** (M 1942; A 1941) Head, Htg., Vtg. and Refrig. Branch, Engrg. Plan Approval Section, U. S. Maritime Commission, 310 S. Michigan Ave., Chicago, and 829 Forest Ave., Evanston, Ill.
- CLAY, Wharton** (M 1939; A 1938) Secy., National Mineral Wool Assn., 1270 Sixth Ave., New York, and 127 S. Broadway, Nyack, N. Y.
- CLAUSEN, Arnold H.** (M 1939) Engr., c/o U. S. Army Engrs., Seattle Dist., Wenatchee, Wash.
- CLEGG, Carl** (M 1922) Dist. Mgr., American Blower Corp., 711 Mutual Bldg., and 3513 Gillham Rd., Kansas City, Mo.
- CLEMENS, Joseph D.** (J 1942; S 1940) 1st Lt., U. S. Army, A. C., Gulfport Field, Miss.
- CLEMENT, Eugene R., Sr.** (A 1924) Pres., E. R. Clement, Inc., 3925 Main St., and 72 Griffen Ave., Bridgeport, Conn.
- CLIFTON, John A.** (A 1938) Mgr., Renown Plumbing Supplies, Ltd., 236 Parliament St., and 389 Belsize Dr., Toronto, Ont., Canada.

ROLL OF MEMBERSHIP

- CLO, Harry E.** (A 1943; J 1939) Ind. Specialist, Office of Industry Operations, Gen. Ind. Equip. Div., Room 1612, Temporary Bldg. 5, War Production Board, and •1700 Webster St. N.W., Washington, D. C.
- CLOSE, Paul D.*** (M 1928) Tech. Secy., •Insulation Board Institute, 111 W. Washington St., Chicago, and 757 Maclean Ave., Kenilworth, Ill.
- CLOSE, Robert** (M 1938) Chief Air Cond. Engr., National Broadcasting Co., 30 Rockefeller Plaza, New York, N. Y., and •185 Glenwood Ave., Leonia, N. J.
- CLOW, Sherwood A.** (J 1942) 2nd Lt., •Signal Corps, Signal Officer, Camp Wolters, Texas, and 109 N. Chatsworth Ave., Larchmont, N. Y.
- COCHRAN, L. H.** (M 1934) Dist. Mgr., •American Blower Corp., 625 Market St., and 130 Camino Del Mar, San Francisco, Calif.
- COCKINS, William W.** (A 1941; J 1937) Engr., Scott Co., 243 Minna St., San Francisco, and •1700 Madera St., Berkeley, Calif.
- CODY, Henry C.** (M 1936) Sales Engr., B. H. Deacon Co., Inc., American and Huntingdon Sts., and •7336 North 21st St., Philadelphia, Pa.
- COE, Seymour A.** (S 1942) Student, •Pratt Institute, 291 Ryerson St., Brooklyn, N. Y., and 54 Waverly St., New Haven, Conn.
- COGHLAN, Sherman F.** (A 1937) Mech. Engr., J. M. Montgomery & Co., 306 W. Third St., Los Angeles, and •414 Ninth St., Santa Monica, Calif.
- COHAGEN, Chandler C.** (M 1919) Archt., •Chandler & Cohagen, Box 2100, and 235 Avenue G, Billings, Mont.
- COHEN, Philip** (M 1932) Dist. Mgr., •B. F. Sturtevant Co., 401 E. Ohio Gas Bldg., and 7100 Euclid Ave., Suite No. 6, Cleveland, Ohio.
- COHN, Henry** (J 1942) Air Cond. Engr., Giffell & Vallett, Inc., Marquette Bldg., and •3410 Chicago Blvd., Detroit, Mich.
- COLBY, John H.** (J 1939) Sales Engr., •Johnson Service Co., 20 Winchester St., Boston, and 25 Jefferson Rd., Wellesley Hills, Mass.
- COLCLOUGH, Otto T.** (A 1933) Custodian, •American Foreign Service, American Legation, and 399 Hamilton Ave., Ottawa, Ont., Canada.
- COLE, C. Boynton** (M 1940; J 1937) Owner, Boynton Cole, Contracting Engr., 1873 Piedmont Rd. N.E., and •1843 Flagler Ave. N.E., Atlanta, Ga.
- COLE, Grant E.** (A 1925) Vice-Pres. and Gen. Mgr., •Trane Co. of Canada, Ltd., 4 Mowat Ave., and 112 Tyndall Ave., Toronto, Ont., Canada.
- COLEMAN, John B.** (M 1920) Chief Engr., •Grinnell Co. Inc., 275 W. Exchange St., and 237 Cole Ave., Providence, R. I.
- COLFORD, John** (A 1937) Pres., John Colford, Ltd., 2007 Guy St., Montreal, and •51 Upper Bellevue Ave., Westmount, Que., Canada.
- COLLE, S. S.** (A 1938) Engr., •Air Conditioning Engineering Co., 361 Youville Sq., and 4963 Fulton St., Montreal, Que., Canada.
- COLLIER, William I.** (M 1921) Mech. Engr., •W. I. Collier & Co., 3414 Duvall Ave., Baltimore, and Ellicott St., Ellicott City, Md.
- COLLINS, John F. S., Jr.** (M 1933) (Council, 1940-42) Secy.-Treas., National District Heating Assn., 827 N. Euclid Ave., Pittsburgh, Pa.
- COLLINS, Leo F.** (M 1941) Chemist, •The Detroit Edison Co., 2000 Second Ave., and 14615 Prevost, Detroit, Mich.
- COLMAN, Robert C.** (A 1940) Vice-Pres., McQuay Inc., 1600 Broadway N.E., Minneapolis, and •102 Exceter Pl., St. Paul, Minn.
- COLMENARES, Gaspar Vizoso** (A 1938) Vice-Pres. and Gen. Mgr., •Castel-Vizo, Refrigeracion y Aire Acondicionado, S. A., Obrapia 407, P. O. Box 210, and Calle 10 No. 34, Miramar, Havana, Cuba.
- COMO, Jack A.** (M 1939) Mech. Engr., •Independent Plumbing Co., 171 Luckie St. N.W., and 2865 Elliot Circle N.E., Atlanta, Ga.
- COMSTOCK, Glen M.** (A 1926) Sales Engr., •L. J. Wing Manufacturing Co., 1319 Murdock Rd., (17), Pittsburgh, Pa.
- CONATY, Bernard M.** (M 1935) Vice-Pres., •American District Steam Co., North Tonnawanda, and P. O. Box 342, Eden, N. Y.
- CONKLIN, Robert N.** (J 1940) Engr., 848 South 14th St., Newark, N. J.
- CONNELL, Richard F.** (M 1916) Mgr., •Capitol Testing Lab., U. S. Radiator Corp., 1056 National Bank Bldg., and 2970 Burlingame, Detroit, Mich.
- CONNER, Raymond M.** (M 1931) Dir. A. G. A. Labs., •American Gas Assn., 1032 East 62nd St., and 2459 Dysart Rd., Cleveland, Ohio.
- CONNORS, Edward C.** (A 1940) Engr. Custodian, Chicago Board of Education, 5500 Madison St., and •6556 Ponchartrain Blvd., Chicago, Ill.
- CONRAD, Roy** (M 1935) Sales Engr., Carrier Corp., 1500 S. Santa Fe., Los Angeles, Calif., and •3421 Bella Vista Ave., Seattle, Wash.
- CONSTANT, Earl S.** (A 1942; J 1935) Engr., Buffalo Forge Co., 490 Broadway, and •242 N. Park Ave., Buffalo, N. Y.
- CONVERSE, Thornton J.** (M 1941) Engr., •Office of Douglas Orr, Archt., 96 Grove St., New Haven, and Stoney Creek, Conn.
- COOK, Benjamin F.** (M 1920) Prop., Benjamin F. Cook, Consulting Engr., 114 W. Tenth St. Bldg., Kansas City, and •1720 Overton Ave., Independence, Mo.
- COOK, Henry D.** (A 1938) Field Engr., •General Controls Co., 450 E. Ohio St., Chicago, Ill., and 73 E. Tenth St., Holland, Mich.
- COOK, Ralph P.** (M 1930) Asst. Supt., Engrg. and Maintenance Dept. in charge of Engrg. Div., •Eastman Kodak Co., Kodak Park, and 663 Seneca Pkwy., Rochester, N. Y.
- COOLEY, Edgerton C.** (M 1938) Mfrs. Agent, •E. C. Cooley Co., 625 Market St., San Francisco, and P. O. Box 789 B, Route 1, Los Altos, Calif.
- COOMBE, James** (A 1932) Pres., •William Powell Co., 2525 Spring Grove Ave., and 2363 Grandin Rd., Cincinnati, Ohio.
- COON, Thurlow E.** (M 1916) Pres., •The Coon-DeVisser Co., Inc., 2051 W. Lafayette, and 826 Edison Ave., Detroit, Mich.
- COOPER, Dale S.** (M 1938; A 1937) Consulting Engr., 216 E. Cowan Dr., Houston, Texas.
- COOPER, Donald E.** (J 1939) Partner, •D. E. Cooper & Son, 540 Hood St., Salem, and 1010 Southeast 54th, Portland, Ore.
- COOPER, John W.** (M 1932; A 1925; J 1921) Repr., •Buffalo Forge Co., 1598 Arcade Bldg., St. Louis, and 612 Hawbrook Dr., Kirkwood, Mo.
- COOPERMAN, Edward** (J 1943; S 1940) U. S. Navy, and •3120 Avalon St., Pittsburgh, Pa.
- COPPERUD, Edmund R.** (A 1942; J 1933) Asst. Mgr., Minneapolis Plumbing Co., 1420 Nicollet Ave., and •17 West 25th St., Minneapolis, Minn.
- CORNWALL, George I.** (Life Member; M 1919) Sales Engr., Burnham Boiler Corp., 701 Spring St., Elizabeth, N. J.
- CORRIGAN, James A.** (A 1940; J 1935; S 1930) Treas. and Chief Engr., •Corrigan Co., 2501 W. St. Louis Ave., and 7128 Washington Ave., St. Louis, Mo.
- COST, George W.** (J 1939; S 1938) U. S. Army, Pennsylvania Ave. Extension, Irwin, Pa.
- COVER, E. B.** (M 1937) Mech. Engr., Consulting Engineering, First National Bank Bldg., and •3252 Waverly, East St. Louis, Ill.
- COVER, Richard R.** (A 1936) U. S. Navy, Warrant Officer, E. V. (s) U. S. N. R., and 1914 N. Upton St., Arlington, Va.
- COWARD, Charles W.** (M 1935) Pres., •Coward Engineering Co., 411 Cooper St., Camden, and Cherry Lane, Riverton, N. J.
- COX, Samuel F.** (M 1939) Tech. Dir., •Double Glazing Div., Pittsburgh Plate Glass Co., 2200 Grant Bldg., and 6049 Bunkerhill St., Pittsburgh, Pa.
- COX, Vernon G.** (A 1939) Major C. A. C., •Hdq. 29, C. A. T. Bn., Camp Wallace, and 207 Yarmouth St., Dallas, Texas.

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- COX, William W.** (*Life Member*; M 1923) Pres. and Mgr., •Heating Service Co., Inc., 326 Columbia St., and 6232-31st Ave. N.E., Seattle, Wash.
- CRAIG, Joseph A.** (J 1940) Sales •The Trane Co., 850 Cromwell Ave., St. Paul, and 829 Eighth St. S., Minneapolis, Minn.
- CRANE, Robert S.** (M 1938) Asst. Sales Mgr., Economy Pumps, Inc., 1000 Weller St., Hamilton, Ohio.
- CRAWFORD, Arthur C.** (A 1938) Capt. Q. M. C., Hq. S. O. S., A. P. O. 871, c/o Postmaster, New York, N. Y., and •429 Butternut St. N.W., Washington, D. C.
- CRAWFORD, John H., Jr.** (A 1936; J 1930) 289 Reynolds Terrace, Orange, N. J.
- CRESSY, L. Villere** (M 1940) Partner, •L. Villere Cressy & Lewis S. Alcus, 3217 De Soto St., New Orleans, La.
- CREW, F. D.** (J 1941) Pres., The F. D. Crew Co., Schaff Bldg., Philadelphia, and •6 Abrahams Rd., Ithaca, Pa.
- CRIQUI, Albert A.*** (M 1919) Chief Engr., Htg. and Vtg. Dept., Buffalo Forge Co., 490 Broadway, Buffalo, and •39 St. Johns Ave., Kenmore, N. Y.
- CROFT, Huber O.** (M 1941) Head, Dept. Mech. Engrg., University of Iowa, 107 Engrg. Bldg., Iowa City, Iowa.
- CROLEY, Jack C.** (J 1940) 1st Lt., •76th Coast Artillery, U. S. Army, Fort Bragg, N. C., and 406 E. Temple Ave., College Park, Ga.
- CRONE, Charles E.** (M 1922) Pres., •Charles E. Crone Co., 1656 N. Ogden Ave., Chicago, and R. R. 2, Frairie View, Ill.
- CRONE, Thomas E.** (*Life Member*; M 1920) Retired, 164th and Chapin Pkwy., Jamaica, L. I., N. Y.
- CRONEY, P. Alfred** (M 1938) Senior Mech. Engr., Federal Public Housing Authority, 24 School St., Boston, and •72 Arlington St., Newton, Mass.
- CROPPER, Robert O.** (M 1938) 1st Lt., •Q. M. C., 12th Q. M. Regt., Camp Lee, Va., and 300 River Rd., Matoaca, Va.
- CROSBY, Edward L.** (M 1936) Pres., •Henry Adams, Inc., 403-407 Calvert Bldg., and 700 Brookwood Rd., Baltimore, Md.
- CROSS, Freeman G.** (M 1938) General Sales Mgr., •Fulton Syphon Co., and 31 Nokomis Circle, Knoxville, Tenn.
- CROSS, Robert C.*** (M 1937) •Sears, Roebuck & Co., Dept. 817, 925 S. Homan Ave., Chicago, and 334 Northwood Rd., Riverside, Ill.
- CROSS, Robert E.** (M 1938; A 1931) Dist. Mgr., Minneapolis-Honeywell Regulator Co., 172 Chestnut St., and •68 Kimberly Ave., Springfield, Mass.
- CROUT, Marvin M.** (M 1939; A 1938) Southeastern Mgr., •York Ice Machinery Corp., 412 Houston St., P. O. Box 2210, and 22 Brighton Rd., Atlanta, Ga.
- CRUMLEY, Mearl T.** (M 1941) Asst. Mgr., Mech. Engrg. Dept., Robert & Co., and •4722 Polaris St., Jacksonville, Fla.
- CRUMP, Alvin L.** (M 1937) Sales Engr., •Powers Regulator Co., 2720 Greenwood Ave., Chicago, and 2701 Payne St., Evanston, Ill.
- CUCCI, Victor J.** (M 1930) Consulting Engr., •30 Church St., New York, and 451-55th St., Brooklyn, N. Y.
- CULBERT, William P.** (A 1929) Partner, •Culbert-Whitby Co., 2019 Rittenhouse St., Philadelphia, and 929 Alexander Ave., Drexel Hill, Pa.
- CULLEN, A. G.** (M 1939; A 1936) Executive, •Cullen Co., 20 L St. S.W., Washington, D. C., and 6826 North 19th Rd., East Falls Church, Va.
- CULLIN, William W.** (M 1938) Chief Engr., Home Insulating Div., Johns-Manville Sales Corp., 22 East 40th St., New York, and •35 Wildwood Ave., Mt. Vernon, N. Y.
- CUMMING, Robert W.** (M 1928) Sales Executive, Sarc Co., Inc., 475 Fifth Ave., New York, and •81 Alkamont Ave., Scarsdale, N. Y.
- CUMMINGS, Carl H.** (A 1927; J 1926) Pres., •Industrial Appliance Co. of New England, 110 Arlington St., Boston, and 41 Edgehill Rd., Chestnut Hill, Mass.
- CUMMINGS, G. J.** (M 1923) Executive Vice-Pres. and Secy., •The Scott Co., 113 Tenth St., and 851 Trestle Glen Rd., Oakland, Calif.
- CUMMINGS, Robert J.** (J 1940) Engr. and Estimator, •Franck & Fric Co., 9334 Kinsman Rd., Cleveland, and 18109 Mapleboro Ave., Bedford, Ohio.
- CUMMINGS, Thomas P.** (A 1942) Engineering Dept., North American Aviation Co., Inglewood, and •5145 Seventh Ave., Los Angeles, Calif.
- CUMMINS, George H.** (M 1919) Dist. Mgr., •Aerofin Corp., 1116 United Artists Bldg., and 16210 Ashton Rd., Detroit, Mich.
- CUMMISKEY, Jerome F.** (A 1940) Sales, Minneapolis-Honeywell Regulator Co., 2405 N. Maryland, and •4433 N. Cramer St., Milwaukee, Wis.
- CUMNOCK, H.** (A 1938) Pres., Little Rock Refrigeration Co., 417 W. Capitol Ave., Little Rock, Ark.
- CUNNINGHAM, John S.** (A 1941; J 1937; S 1935) Chief Engr., Dowagiac Steel Furnace Co., and •205 Spruce St., Dowagiac, Mich.
- CUNNINGHAM, Thomas M.** (M 1931; J 1930) Production Mgr., Carrier Corp., Room 2200, 20 N. Wacker Dr., Chicago, Ill.
- CURL, Robert S.** (A 1941) Engr., Austin Co., Cleveland, and •3242 Sycamore Rd., Cleveland Heights, Ohio.
- CURLEY, Ellis I.** (A 1941) •U. S. N. R., Lehigh University, Bethlehem, and 69 E. Lancaster Ave., Ardmore, Pa.
- CURRY, Roger F.** (J 1940; S 1938) Curtiss Wright Corp., Buffalo, and •294 Crosby Ave., Kenmore, N. Y.
- CURTICE, Jean M.** (A 1936) Dist. Mgr., •Citizens Utilities Co., 15 W. Fourth St., and 906 Lincoln Ave., La Junta, Colo.
- CURTIS, Herbert F.** (A 1934) Sales Mgr., •Auer Register Co., 3608 Payne Ave., Cleveland, and 59 Fourth Ave., Berea, Ohio.
- CUSHING, C. F.** (M 1938) Sales Promotion Mgr., •The Bryant Heater Co., 17825 St. Clair Ave., and 13415 S. Woodland Ave., Cleveland, Ohio.
- CUSHING, R. C.** (A 1940) Sales Engr., •Minneapolis-Honeywell Regulator Co., 1136 Howard St., San Francisco, and 3014 Benvenue Ave., Berkeley, Calif.
- CUTLER, Joseph A.** (M 1916) (Council, 1920-26) Pres., •Johnson Service Co., 507 E. Michigan St., and 4811 N. Lake Dr., Milwaukee, Wis.
- CUTTING, Richard H.** (M 1942) Archt. Engr., Architecture & Engrg., 915 National City Bank Bldg., Cleveland, and •3795 Glenwood Rd., Cleveland Heights, Ohio.

D

- DABBS, John T.** (A 1940) 1st Lt., C. A. C., c/o Postmaster, A. P. O. 937, Seattle, Wash., and •330 N. Green St., Tupelo, Miss.
- DADDARIO, Frank T.** (J 1939) Chief Air Cond. Engr., •Carolina Engineering Co., 220 Trust Bldg., and 104 Briar-Cliff Rd., Durham, N. C.
- DAFTER, Edwin H.** (M 1938) Sales Engr., •Carrier Corp., 12 South 12th St., and 117 Crosshill Rd., Overbrook Hills, Philadelphia, Pa.
- DAHLGREN, Gustave E.** (A 1940) Insulation Mgr., •Thorkelsson, Ltd., 1331 Spruce St., and 492 Sprague St., Winnipeg, Man., Canada.
- DAHLSTROM, Godfrey A.** (A 1927) Asst. Engr., Smith, Hinchman & Grylls, Inc., and Toltz, King & Day, Inc., Twin City Ordnance Plant, St. Paul, and •3721-47th Ave. S., Minneapolis, Minn.
- DAITSH, Abe** (J 1938) Air Cond. and Refrig. Engr., •General Assurance Bldg., 86 St. George's St., Cape Town, South Africa.
- DALY, Robert E.** (M 1931) •American Radiator & Standard Sanitary Corp., P. O. Box 1226, Pittsburgh, and 271 Kenforest Dr., Mt. Lebanon, Pa.

ROLL OF MEMBERSHIP

- D'AMBLY, A. Ernest** (M 1924; J 1921) Owner, •A. Ernest D'Ambly, 2101 Architects Bldg., and 1835 DeLancey St., Philadelphia, Pa.
- DANIEL, William E.** (A 1941; J 1939) Junior Partner, •E. Ashby & Co., 20 Upper Ground, Black Friars, London, and 91 Dudley House, Westmoreland St., London, W. 1, England.
- DANIELSON, Wilmot A.*** (M 1935) Brig. General, Memphis Quartermaster Depot, Memphis, Tenn.
- DANOWITZ, Chester J.** (J 1942) Asst. Naval Archt., Supervisor of Shipbuilding, U. S. N., Camden, N. J. and •106 Knight Ave., Collingswood, N. J.
- DARLING, A. B.** (A 1929) Comptroller, •Darling Brothers, Ltd., 140 Prince St., and 4009 Grey Ave., Montreal, Que., Canada.
- DARLINGTON, Allan P.** (M 1930) Mgr., Power Equip. Div., •American Blower Corp., 8111 Tireman Ave., Dearborn, and 17511 Santa Rosa Dr., Detroit, Mich.
- DARTS, John A.** (M 1919) Kewanee Boiler Co., Inc., 101 Park Ave., New York, N. Y.
- DASING, Emil** (M 1937) Design Engr., Sears, Roebuck & Co., 925 S. Homan Ave., and •4729 N. Talman Ave., Chicago, Ill.
- DAUBER, Oscar W.** (M 1937) Consulting Engr., •224 S. Michigan Ave., Chicago, and 532 Greenwood Ave., Kenilworth, Ill.
- DAUCH, Emil O.** (M 1921) Pres., •McCormick Plumbing Supply Co., 1675 Bagley Ave., and 729 Bedford Rd., Grosse Point Park, Detroit, Mich.
- DAVEY, Geoffrey I.** (M 1937) Consulting Engr., •Haskins, Davey & A. G. Gutteridge, 60 Hunter St., and "Letherby," Bangalla St., Warrawee, Sydney, Australia.
- DAVIDSON, John C.** (M 1940; J 1936) Lt. (jg) U. S. N. R., Sr. Asst. Personnel Officer, Norfolk Navy Yard, Personnel Dept., and •8274 Gyax Rd., Norfolk, Va.
- DAVIDSON, L. Clifford** (M 1927) Assoc. Dist. Mgr., •Buffalo Forge Co., 220 South 16th St., Philadelphia, and 322 Winding Way, Merion, Pa.
- DAVIDSON, Philip L.** (M 1924; J 1921) Consulting Engr., New Hope, Pa.
- DAVIES, George W.** (M 1918) Mgr., •G. W. Davies & Co., 19 MacLaggan St., Dunedin, C. 1, and P. O. Box 390, Dunedin, N. 2, Colinswood, Macandrew Bay, New Zealand.
- DAVIS, Bert C.** (Life Member; M 1904) (Council, 1917) Pres.-Treas., American Warming & Ventilating Co., 317 Pennsylvania Ave., Elmira, and •Big Flats, N. Y.
- DAVIS, Calvin R.** (M 1927) Branch Mgr., •Johnson Service Co., 2328 Locust St., and 7534 Westmoreland Dr., St. Louis, Mo.
- DAVIS, Charles** (M 1938) Engr., James H. Merritt & Co., Inc., 396 Broadway, and •245 East 180th St., New York, N. Y.
- DAVIS, Clemant A. L.** (A 1942) Mgr., H. F. Dept., John H. Kitchen & Co., 1016 Baltimore, and •5441 Jackson, Kansas City, Mo.
- DAVIS, Donald W., Jr.** (J 1939) Dist. Mgr., •B. F. Sturtevant Co., 832 Empire Bldg., and 840 E. Henry Clay St., Milwaukee, Wis.
- DAVIS, Edward J.** (A 1943; J 1938) Sales Engr., Gurney Foundry Co., Ltd., 4 Junction Rd., and •224 St. Clements Ave., Toronto, Ont., Canada.
- DAVIS, George C.** (M 1939; J 1936) Vice-Pres., •Northern Public Service Corp., Ltd., 307 Power Bldg., and 366 Ash St., Winnipeg, Man., Canada.
- DAVIS, George L., Jr.** (A 1938) Estimator, R. L. Spitzley Heating Co., 1200 W. Fort St., Detroit, and •1220 Beaconsfield St., Grosse Point Park, Mich.
- DAVIS, Joseph** (M 1927; A 1926) Owner, Engr. and Contractor, and Pres. and Treas., •Davis Refrigeration Co., Inc., 70 W. Chippewa St., and 166 Huntington Ave., Buffalo, N. Y.
- DAVIS, Keith T.** (M 1937) Chief Engr., •L. J. Mueller Furnace Co., Milwaukee, and 1500 E. Marion, Shorewood, Wis.
- DAVIS, Otis E.** (M 1929; A 1925) Sales Engr., •Hoffman Specialty Co., Box 98, and 1502 Fourth Ave., Scottsbluff, Nebr.
- DAVIS, Telford R.** (M 1942) Mech. Engr., Indianapolis Power & Light Co., 1230 W. Morris St., and •1311 N. Drexel, Indianapolis, Ind.
- DAVISON, Robert L.** (M 1934) Dir. of Research, •John B. Pierce Foundation, 40 West 40th St., New York, and Meadow Glen Rd., Fort Salonga, L. I., N. Y.
- DAWSON, Eugene F.** (M 1934) Prof. of Mech. Engr., Dir. School of Mech. Engr., •University of Oklahoma, and 701 N. Porter St., Norman, Okla.
- DAY, Harold C.** (A 1934) Mgr., American Radiator & Standard Sanitary Corp., 1807 Elmwood Ave., Buffalo, N. Y.
- DAY, Irving M.** (A 1936) Sales Engr., •Binks Manufacturing Co., 718 Mills Bldg., Washington, D. C., and 405 Cumberland Ave., Chevy Chase, Md.
- DAY, V. S.*** (M 1924) Asst. to Vice-Pres., •Carrier Corp., S. Geddes St., and 316 Highland Ave., Syracuse, N. Y.
- DEAN, Carl H.** (M 1936) Htg. Engr., •Oklahoma Natural Gas Co., Box 871, and 1532 East 35th St., Tulsa, Okla.
- DEAN, Charles L.** (M 1932) Assoc. Prof. Mech. Engr., University of Wisconsin, 305 University Extension Bldg., and •102 Grand Ave., Madison, Wis.
- DEAN, David** (M 1937) 171 Radford St., Yonkers, N. Y.
- DEAN, Frank J., Jr.** (A 1942; J 1935; S 1934) Pres., Dean-Hagney Corp., 14th and Magee St., and •6028 Walnut St., Kansas City, Mo.
- DEAN, Marshall H.** (J 1938; S 1936) Secy.-Treas., Temperature Engineering Co., 1338 McGee St., and 209 East 46th St., Kansas City, Mo.
- DeBERARD, Philip E.** (A 1939) Pres., •Conditioned Air Systems, Inc., 1209 Washington Ave., and 1609 Tenth St., Wilmette, Ill.
- DEEVES, Edward W.** (J 1940) Partner •Fred Deeves & Sons, 1422A-17th Ave. W., and 2403 33rd St. W., Calgary, Alta., Canada.
- DeFLON, James G.** (J 1942) Cooling Tower Engr., The Fluor Corp., 2500 S. Atlantic Blvd., and •6209 Northside Dr., Los Angeles, Calif.
- DeLAND, Charles W.** (M 1924; J 1923) Secy.-Treas., •C. W. Johnson, Inc., 211 N. Desplaines St., and 2021 Estes Ave., Chicago, Ill.
- DeLAUREAL, William D.** (J 1940) Mgr. Air Cond. Dept., Gulf Engineering Co., 916 S. Peters St., and •4821 Pitt St., New Orleans, La.
- DEMAREST, Richard T.** (J 1938) Engr., Government Dept., •Fitzgibbons Boiler Co., Inc., 101 Park Ave., and 1-11 Marble Hill Ave., New York, N. Y.
- deMENA, L. Isabel** (A 1942) Student, National School, and •1287½ Plymouth Blvd., Los Angeles, Calif.
- DEMETER, Julius** (A 1939) c/o Julio Donoso D., Calle Catedral 1472, Santiago, Chile, South America.
- DEMING, Roy E.** (M 1941; A 1939) Chief Engr., Premier Furnace Co., and •107 Jay St., Dowagiac, Mich.
- DEMPSEY, Stephen J.** (A 1938) •Stephen J. Dempsey Co., 79 Harvard St., Battle Creek, Mich.
- DENHAM, Howard S.** (M 1939) Mech. Checker, Stone & Webster, 149 Federal St., Boston, and •80 Dexter St., Malden, Mass.
- DENNY, Harold R.** (A 1934) Eastern Merchandise Mgr., •American Blower Corp., 50 West 40th St., New York, N. Y., and 429 Edgewood Ave., Westfield, N. J.
- DEPPMANN, Ray L.** (A 1937) Owner, •R. L. Deppmann Co., 5853 Hamilton Ave., and 13201 Cloverlawn Ave., Detroit, Mich.
- DERER, Bernard** (A 1940) Designer and Estimator, New Brunswick Roofing & Cornice Works, 9-10 Jelin St., New Brunswick, N. J., and •1242 Ocean Ave., Brooklyn, N. Y.
- DeSALES, Monteiro, Jr.** (M 1939) Chief Engr., •Isnard & Co., Rua de Lavradie 67 1°, and Rua Senador Vergueire 193 2°, Rio de Janeiro, Brazil, South America.

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- DeSOMMA, A. Edward** (A 1943; J 1937) Assoc. Engr., Navy Dept., Bureau of Ships, Washington, D. C., and •619 Greenwood Ave., Takoma Park, Md.
- Des REIS, John F.** (M 1936) Regional Mgr., •Latin America Carrier Corp., and 103 Huntleigh Park Dr., Fayetteville, N. Y.
- DETERLING, W. C.** (A 1937) Section Head, Industrial Dept., •General Electric Co., 570 Lexington Ave., New York, and 32 W. Milton St., Freeport, L. I., N. Y.
- DEVER, Henry F.** (M 1936; A 1935) Vice-Pres. in charge of Engrg., Minneapolis-Honeywell Regulator Co., and •4609 Edina Blvd., Minneapolis, Minn.
- DEVLIN, John** (M 1940) Partner, •Devlin Bros., 1003 Maritime Bldg., and 5100 Pitt St., New Orleans, La.
- DEVORE, Angus B.** (A 1937) Sales Engr., •James A. Messer Co., Inc., 1206 K St. N.W., and 4817-36th St. N.W., Washington, D. C.
- DeWITT, Earl S.** (A 1936) •American Blower Corp., 1211 Commercial Bank Bldg., and 2323 Briarwood Rd., Charlotte, N. C.
- DIAMOND, David D.** (A 1942; J 1937) Pvt., 801st S. S. R. Bks. 151, Co. H., Camp Murphy, Fla.
- DIBBLE, Samuel E.*** (M 1917) (*Presidential Member*) (Pres., 1925; 1st Vice-Pres., 1924; 2nd Vice-Pres., 1922; Council, 1921-26) Supt., Thomas Ranken Patton School, Elizabethtown, Pa.
- DICK, Harold S.** (J 1942; S 1940) Air Cond. Engr., Keystone Sheet Metal Works, 319 Academy St., Newark, and •1235 Park Ave., Hoboken, N. J.
- DICKASON, Gray D.** (M 1938) Pres.-Treas., •Genesee Heating Service, Inc., 950 Mercantile Bldg., and 140 Windemere Rd., Rochester, N. Y.
- DICKENS, Lester A.** (A 1941) Treas., •Dickens Scheuffer Burens, Inc., 3959 Mayfield Rd., and 3710 Grosvenor Rd., Cleveland Heights, Ohio.
- DICKENSON, Malcolm E.** (M 1936) Pres. and Gen. Mgr., •Livingston Stoker Co., Ltd., 33 Sanford Ave. S., and 964 Cumberland Ave., Hamilton, Ont., Canada.
- DICKEY, Arthur J.** (M 1921) Vice-Pres., Gen. Mgr., C. A. Dunham Co., Ltd., 1523 Davenport Rd., and •9 Mossom Pl., Toronto, Ont., Canada.
- DICKINSON, Robert P., Jr.** (J 1938) Sales Engr., •Burnham Boiler Corp. of Ohio, 301 Brushstn Ave., and 521 S. Lang Ave., Pittsburgh, Pa.
- DICKSON, Donald R.** (S 1941) Student, •Purdue University, 268 Littleton St., W. Lafayette, and 44 East 37th St., Indianapolis, Ind.
- DICKSON, George P.** (M 1919) B. F. Sturtevant Co., Camden, N. J.
- DICKSON, Robert B.** (M 1919) Pres., •Kewanee Boiler Corp., and 145 E. Division St., Kewanee, Ill.
- DICKSON, Robert W., Jr.** (A 1943; J 1938) Lt., U. S. Army, •40th Bombardment Group, Borinquen Field, Puerto Rico, and 1841 Oliver Bldg., Pittsburgh, Pa.
- DIETER, George H.** (M 1941) Engrg. Dept., The Fluor Corp., Ltd., P. O. Box 7030, E. Los Angeles Branch, Los Angeles, Calif.
- DIETZ, C. Fred** (M 1938) Sales Engr., •Haynes Selling Co., Inc., 1124 Spring Garden St., and 1215 Allengrove St., Philadelphia, Pa.
- DILL, Richard S.*** (M 1939) Chief, Heat Transfer Section, National Bureau of Standards, Washington, D. C., and •1603 S. Springwood Dr., Silver Spring, Md.
- DILLENDER, Eugene A.** (M 1939) Engr., United States Engineer Office, and •1152 Menlo Ave., Los Angeles, Calif.
- DION, Alfred M.** (M 1937) Sales Engr., •Trane Co. of Canada, King and Mowat Sts., and 540 Russell Hill Rd., Toronto, Ont., Canada.
- DISNEY, Melvin A.** (M 1942; A 1934) Plbg., Htg., Vent., and Refrig. Engr., War Dept., U. S. Engr. Corps., and •4905½, Galveston, Texas.
- DISTEL, Robert E.** (M 1941; J 1938) Gen. Mgr., Distel Heating Equipment Co., 404-406 Kalamazoo Plaza, Lansing, and 547 Bailey St., East Lansing, and •P. O. Box 133, Lansing, Mich.
- DIVER, M. L.** (M 1925) Consulting Engr., P. O. Box 1016, San Antonio, Texas.
- DIXON, Arthur G.** (M 1928) Mgr. Htg. Div., •Modine Manufacturing Co., and 442 Wolff St., Racine, Wis.
- DODDS, Forrest F.** (M 1920) Mgr., •American Radiator & Standard Sanitary Corp., 503-6 National Fidelity Life Bldg., 1002 Walnut St., and 4600 Mill Creek Pkwy., Kansas City, Mo.
- DODGE, Harry A.** (M 1936) Elec. Engr., S. H. Kress & Co., 114 Fifth Ave., and •514 West End Ave., New York, N. Y.
- DOERING, Frank L.** (M 1919) Sales Repr., American Radiator & Standard Sanitary Corp., 238 Boston Ave., Lynchburg, Va.
- DOHERTY, John J.** (A 1942) Treas., •Fells Plumbing & Heating Co., Inc., 654 Main St., and 194 Forest St., Winchester, Mass.
- DOLAN, Raymond G.** (M 1926; J 1922) Secy.-Treas., •Tom Dolan Heating Co., Inc., 614-16 W. Grand, and 708 N.W. 40th., Oklahoma City, Okla.
- DOLAN, William H.** (A 1941; J 1927) Pres., •The Jennison Co., 17 Putnam St., and 65 Highland Ave., Fitchburg, Mass.
- DOMÉ, Alan G.** (A 1938; J 1936) Air Cond. Engr., Bryant Air Conditioning Corp., 915 N. Front St., and •314 E. Allen's Lane, Philadelphia, Pa.
- DOMINY, Charles B.** (J 1942) Asst. Engr., Puget Sound Navy Yard, Bremerton, and •P.O. Box 556, Castle Apts. No. 102, Bremerton, Wash.
- DONELSON, William N.** (A 1943; J 1937) Engr., Modine Manufacturing Co., and •Route 3, Box 89, Racine, Wis.
- DONNELLY, James A.*** (*Life Member; M 1904*) (Treas., 1912-14; Board of Governors, 1913; Council, 1914) Largent, W. Va.
- DONNELLY, Russell** (M 1923) Sales Engr., Nash Engineering Co., Graybar Bldg., 420 Lexington Ave., New York, N. Y.
- DONOHUE, Charles F.** (M 1941) Engr., Central Heating Dept., •The Detroit Edison Co., 2000 Second Ave., Detroit, and 10065 Lincoln Dr., Huntington Woods, Mich.
- DONOHUE, John B.** (A 1937; J 1935) Engr., and Estimator, •B. F. Donohoe & Co., 51 Albany St., Boston, and 23 Primrose St., Roslindale, Mass.
- DONOVAN, William J.** (A 1930) 2239 North 27th St., Philadelphia, Pa.
- DORFAN, Morton I.** (M 1929) Consulting Engr., Room 200, 336 Fourth Ave., Pittsburgh, and Vice-Pres. and Gen. Mgr., Coated Products Corp., Verona, and •1217 Malvern Ave., Pittsburgh, Pa.
- DORNHEIM, G. A.** (M 1912; J 1906) Buensod-Stagey Air Conditioning, Inc., 60 East 42nd St., New York, and •15 Hamilton Ave., Bronxville, N. Y.
- DORSEY, Francis C.** (M 1920) Pres., •Francis C. Dorsey, Inc., 4520 Schenley Rd., and 212 Gittings Ave., Baltimore, Md.
- DOSTER, Alexis** (A 1934) Vice-Pres., and Secy., •The Torrington Manufacturing Co., 70 Franklin St., Torrington, and Litchfield, Conn.
- DOUGHTY, Charles J.** (M 1925) Asst. Project Mech. Engr., •The Austin Co., Box 1926, and 2516 N. Hudson, Apt. 202, Oklahoma City, Okla.
- DOVENER, Robert F.** (A 1941) Engr., •Atchison & Keller, 1416 Irving St. N.W., Washington, D. C., and 5012 Yorktown Rd., Greenacres, Md., and P. O. Friendship Station, D. C.
- DOWDELL, J. R.** (A 1941) Owner, •J. R. Dowdell & Co., 1003 Southwestern Life Bldg., and 4400 Windsor Pkwy., Dallas, Texas.
- DOWDY, Rufus B.** (M 1939) Sales Engr., •Haydn Myer Co., Inc., P. O. Box 746, and 203 Capitol Pkwy., Montgomery, Ala.

ROLL OF MEMBERSHIP

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DOWNES, Alfred H. (*A* 1937) Draftsman, Gay Engineering Corp., 2730 East 11th St., and •1342½ Bond St., Los Angeles, Calif.

DOWNES, H. H. (*M* 1923) Dist. Mgr., •American Blower Corp., 438 Woodward Bldg., and Lee Sheraton Hotel, Washington, D. C.

DOWNES, Nate W. (*M* 1917) (Council, 1928-30) Asst. Supt. in charge Bldgs. and Grounds, School Dist. of Kansas City, •317 Finance Bldg., and 2119 East 68th St., Kansas City, Mo.

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- FOSTER, John G.** (J 1938) Lt., 0-439, 706, 8th Photo Squadron, A. P. O. 929, c/o Postmaster, San Francisco, Calif., and •2635 Sedgwick Ave., New York, N. Y.
- FOULDS, P. A. L.** (M 1916) Consulting Engr. (Partner), •110 State St., Boston, and 72 Whitin Ave., Revere, Mass.
- FOWLES, Harry H.** (A 1940; J 1934) Engr., and Estimator, V. J. Kenneally Co., 104 Hanover St., Boston, Mass., and •4 Haskell St., Auburn, Me.
- FOX, Ernest** (M 1935) Asst. Engr., •C. A. Dunham Co., Ltd., 1523 Davenport Rd., and 531 Rushton Rd., Toronto, Ont., Canada.
- FOX, John H.** (M 1935) Major, 2 Cdn. Army Tank Ordnance Company, Canadian Army, and •37 Macdonell Ave., Toronto, Ont., Canada.
- FRANCK, Peter*** (J 1938) Secy., Tiltz Air Conditioning Corp., 230 Park Ave., New York, and •3311A-69th St., Jackson Heights, L. I., N. Y.
- FRANK, John M.** (M 1918; A 1912) Pres., •Ilg Electric Ventilating Co., 2850 N. Crawford Ave., Chicago, and 1152 Chatfield Rd., Hubbard Woods, Ill.
- FRANK, Olive E.*** (M 1919) Pres., •Frank Heaters, Inc., 521 East 40th St., Paterson, and Algonquin Trail, Pines Lake, N. J.
- FRANKEL, Gilbert S.** (M 1926) Mgr., •Federal and Marine Dept., Buffalo Forge Co., 512 Woodward Bldg., Washington, D. C., and 5800 Kirkside Dr., Chevy Chase, Md.
- FRANKLE, Harry R.** (M 1941) Mgr., •Midwest Air Control, 725 Grand Ave., and 547-44th St., Des Moines, Iowa.
- FRANKLIN, Ralph S.** (M 1919) 320 Grove St., Melrose, Mass.
- FRANKLIN, Sam H., Jr.** (A 1938) Major, •1011 Mutual Bldg., Richmond, and 204 Colonial Court, Lynchburg, Va.
- FRASER, James J.** (A 1936) Managing Dir., •Honeywell-Brown, Ltd., Wadsworth Rd., Perivale, Greenford, Middlesex, and 29 Wellesley Rd., Twickenham, England.
- FRAZIER, J. Earl** (A 1936) Vice-Pres., Treas., •Frazier-Simplex, Inc., 436 E. Beau St., and 7 Wilmont Ave., Washington, Pa.
- FREDERICK, Holmes W.** (M 1937) Asst. Htg. Engr., Cornell University, Morrill Hall, and •103 Harvard Pl., Ithaca, N. Y.
- FREEMAN, Alfred W.** (J 1940; S 1939) Lt., 313 Fighter Sqdn., Leesburg, Fla., and •31-05 88th St., Jackson Heights, L. I., N. Y.
- FREEMAN, Edwin M.** (A 1937) Vice-Pres., •Canadian Asbestos Co., 322 Youville Sq., and 66 Courclette Ave., Montreal, Que., Canada.
- FREEMAN, J. Albert** (A 1940; J 1938) Partner, Engr., •Western Engineering Co., 1623 Southeast 11th Ave., and 4436 S.W. Dosch Rd., Portland, Ore.
- FREESTROM, Arthur** (A 1941) Sales Engr., O. Freiret Co., Alpena, Mich.
- FREITAG, Frederic G.** (M 1932) 9 Harrison St., Mt. Vernon, N. Y.
- FRENCH, Donald** (M 1926) Vice-Pres., •Carrier Corp., 302 S. Geddes St., Syracuse, and Box 238, Cazenovia, N. Y.
- FRENTZEL, Herman C.** (M 1936) Chief Engr., and Works Mgr., The Heil Co., 3000 W. Montana St., and •4363 N. Wildwood Ave., Milwaukee, Wis.
- FRIEDLER, Joseph J., Jr.** (M 1940) Southern Dist. Mgr., •Ilg Electric Ventilating Co., 304 Natchez Bldg., and 5411 Fontainebleau Dr., New Orleans, La.
- FRIEDLIEB, Morton J.** (J 1942) Mech. Designer, Madigan-Hyland Co., Ltd., 2804-41st Ave., Long Island City, and •6560 Booth St., Forest Hills, L. I., N. Y.
- FRIEDLINE, James M.** (A 1942; J 1937) 1st Lt., U. S. Army Engineers, and c/o R. L. Dixon, Plymouth, Iowa.

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FRIEDMAN, Ferdinand J.* (M 1921) • McDougall & Friedman, 1221 Osborne St., Montreal, Que., Canada, and 31 Union Square, New York, N. Y.
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GAMBLE, Cary B. (M 1940; A 1935) Gen. Mgr., Associated Mechanical Contractors, Bluebonnet Ordnance Plant, McGregor, and • 2704 Herring Ave., Waco, Texas.
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GANNON, Russell R. (M 1939) Owner, • Russell R. Cannon Co., 223 Gwynne Bldg., and 6442 Grand Vista Ave., Pleasant Ridge, Cincinnati, Ohio.
GANT, H. P.* (M 1915) (Presidential Member) (Pres., 1923; 1st Vice-Pres., 1922; 2nd Vice-Pres., 1921; Council, 1918; 1921-24) Director of Planning, Philadelphia Ordnance District, 150 S. Broad St., Philadelphia, and • R. D. No. 1, Glenmoore, Pa.
GARBER, William E., Jr. (J 1938) Sales Mgr., Farquar Heating Service Co., 3406 E. Tenth St., Indianapolis, and • Rural Route 1, Fairland, Ind.
GARDNER, C. Rollins (A 1937) Vice-Pres., • Martyn Brothers, Inc., 911 Camp St., Dallas, and 4417 E. Lancaster Ave., Fort Worth, Texas.
GARDNER, William (A 1921) Garden City Fan Co., 332 S. Michigan Ave., and • 7836 Loomis Blvd., Chicago, Ill.
GARNEAU, Leo (M 1938; J 1930) Sales Engr., • C. A. Dunham, Ltd., 832 Dominion Square Bldg., Montreal, and 34 Coolbreeze Ave., Lakeside, Que., Canada.

GARRARD, Walter M. (M 1941) Mfrs. Agent, • Garrard & Co., 413 Bona Allen Bldg., and 60 Muscogee Ave. N.W., Atlanta, Ga.
GATES, A. S., Jr. (A 1941) Assoc. Engr. (Naval Archt.), Bureau of Ships, U. S. Navy, Washington, D. C., and • 111 County Rd., Kensington, Md.
GAULEY, Ernest R. (A 1935) Deputy Administrator of Plbg., Htg., and Air Cond. Supplies, Wartime Prices & Trade Board, 410 Victoria Bldg., Ottawa, Canada.
GAULT, George W. (J 1937; S 1934) Capt., C. E., U. S. Army, Engineer School, Fort Belvoir, and • 403 Luray Ave., Alexandria, Va.
GAUSE, H. Chester (M 1937) Ind. Power Engr., • Alabama Power Co., 1002 Alabama Power Co. Bldg., and 3916 Montevallo Rd., Birmingham, Ala.
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GAUSMAN, Carl E. (M 1923) Partner, Gausman & Moore, 1026 First National Bank Bldg., and • 2360 Chilcombe Ave., St. Paul, Minn.
GAYLORD, Frank H. (M 1921) Vice-Pres., • Hoffman Specialty Co., Inc., 130 N. Wells St., Chicago, and 362 N. York St., Elmhurst, Ill.
GAYMAN, Paul D. (M 1938) Branch Mgr., • Johnson Service Co., 2142 East 19th St., and 20875 Endsley Ave., Rocky River, Cleveland, Ohio.
GAYNER, James (M 1937) Consulting Engr., • 260 California St., San Francisco, and 327 Magnolia Ave., Piedmont, Calif.
GEDEL, Kurt M. (S 1940) Draftsman, Anderson & Coffey, Inc., Student, Northeastern University, Boston, Mass., and • 229-120th St., Rockaway Beach, L. I., N. Y.
GEHR, William (A 1939) Branch Mgr., • Johnson Service Co., 320 American Bank Bldg., and 3801 S.E. Woodward St., Portland, Ore.
GEIGER, Irvin H. (M 1919) Registered Professional Engr. and Mfrs. Repr., • 410 Telegraph Bldg., and 24 Macley St., Harrisburg, Pa.
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GERRISH, Grenville B. (A 1936; J 1930) Repr., Fitzgibbons Boiler Co., Inc., 31 Main St., Cambridge, and • 26 Standish Rd., Melrose, Mass.
GERRISH, Harry E. (M 1910) (Council, 1919) Pres., • Morgan-Gerrish Co., 307 Essex Bldg., and 4534 S. Fremont Ave., Minneapolis, Minn.
GERSTENBERGER, Edgar J. (A 1938) Sales Engr., Glendale Supply Co., 1819 W. Glendale Ave., and • 3824 North 17th St., Milwaukee, Wis.
GESSELL, E. T. (M 1941) Sales Engr., • W. E. Lewis & Co., 610 Thomas Bldg., and 2705 Amherst, Dallas, Texas.
GETSCHOW, Roy M. (M 1919) Pres.-Treas., • Phillips-Getschow Co., 32 W. Hubbard St., Chicago, and 122 Woodstock, Kenilworth, Ill.
GEZARI, Zvi (A 1941) Research Dir., Industrial Device Corp., 202 East 44th St., and • 10 West 65th St., New York, N. Y.
GHOSE, Khagendra N. (A 1938) Consulting Engr., 17 State St., New York, N. Y., and • 39 Ramkanta Bose St., Bagh Bazar, Calcutta, India.
GHOSH, Bidhu Bhushan (J 1939) Ind. Planning Officer, War Supply Board, Government of India, 6, Esplanade East, and 15, Lansdowne Terrace, Calcutta, British India.
GIANNINI, Mario C. (M 1935) Asst. Prof. and Dir. of War Training • New York University, University Heights, New York, and 322 Rear Ave., Crestwood, N. Y.

- GIBBONS, Michael J.** (M 1914) Gen. Mgr., M. J. Gibbons Supply Co., 601-631 E. Monument Ave., and •116 Thruston Blvd., Dayton, Ohio.
- GIBBS, Edward W.** (*Life Member*; M 1919) Pres., •The Smith-Gibbs Co., 201 S. Main St., and 39 President Ave., Providence, R. I.
- GIESECKE, F. E.*** (*Life Member*; M 1913) (*Presidential Member*) (Pres., 1940; 1st Vice-Pres., 1939; 2nd Vice-Pres., 1938; Council, 1932-41) Prof. Emeritus, Texas A. & M. College, College Station, Texas, and •Urbana-Lincoln Hotel, Urbana, Ill.
- GIFFORD, Clarence A.** (A 1934) Sales, American Radiator & Standard Sanitary Corp., 1807 Elmwood Ave., Buffalo, and •78 Roycroft Blvd., Snyder, N. Y.
- GIFFORD, Edmund W.** (M 1938) Branch Mgr., Himelblau, Byfield & Co., •611 N. Broadway, Milwaukee, and 2431 North 85th St., Wauwatosa, Wis.
- GIFFORD, Robert L.** (*Life Member*; M 1908) Pres., Illinois Engineering Co., Cor. 21st St. and Racine Ave., Chicago, Ill., and •1231 S. El Molino Ave., Pasadena, Calif.
- GIGURE, George H.** (M 1920) Mech. Engr., •Smith, Hinchman & Grylls, 800 Marquette Bldg., and 2253 Burns, Detroit, Mich.
- GILBERT, Leslie S.** (M 1937) Owner, •Gilbert Engineering Co., 1305 Liberty Bank Bldg., and 3713 Southwestern Blvd., Dallas, Texas.
- GILBERT, Thomas** (A 1940) Repr., Empire Brass Manufacturing Co., Ltd., and •216 Raymond Ave., London, Ont., Canada.
- GILBOY, John P.** (M 1924) Sr. Member, •John P. Gilboy Co., 503 Scranton Electric Bldg., and 521 Arthur Ave., Scranton, Pa.
- GILLETT, M. C.** (M 1916) Dist. Sales Mgr., Hoffman Specialty Co., Inc., and •3444 N. Pennsylvania, Indianapolis, Ind.
- GILLILAND, Lesley** (A 1942) Operating Engr., Gadsden Ordnance Plant, Gadsden, and •Route No. 1, Attalla, Ala.
- GILMAN, Franklin W.** (M 1935) Plant Engr., •Loft Candy Corp., 38-38 Ninth St., Long Island City, L. I., N. Y., and The Chatham, 20th and Walnut Sts., Philadelphia, Pa.
- GILMORE, John L.** (A 1938) Owner, •John L. Gilmore, Htg.-Vtg., 1525 Cochran Ave., and 1604 Union St., Brunswick, Ga.
- GILMORE, Louis A.** (A 1940; J 1935; S 1930) Vice-Pres., John Gilmore & Co., 115 South 11th St., and •7256 Pershing Ave., St. Louis, Mo.
- GINN, Tony M.** (M 1935) Gen. Mgr., Tony M. Ginn Co., 214-24 Fifth St. S., Great Falls, Mont.
- GINZBURG, Nicola** (M 1942) Marine Ventilation Design Engr., The Pusey & Jones Corp., Front and Poplar Sts., Wilmington, and •5 Maple Ave., Claymont, Del.
- GITTERMAN, Henry** (A 1937) Precipitron Specialist, Westinghouse Electric & Manufacturing Co., 40 Wall St., New York, and •Yorktown Heights, N. Y.
- GITTLESON, Harold** (A 1936) Sales Mgr., LaRiviere, Inc., 3715 St. Lawrence Blvd., Montreal, and •1125 Lajoie Ave., Outremont, Que., Canada.
- GIVIN, Albert W.** (A 1925) Vice-Pres. in charge of Sales, The Gurney Foundry Co., Ltd., 4 Junction Rd., Toronto, and •R. R. 2, Freeman, Ont., Canada.
- GJERTSEN, George** (S 1940) Social Security Board, and •4509 Arabia Ave., Baltimore, Md.
- GLASS, William** (M 1934) Pres. and Mgr., •Partridge-Halliday, Ltd., 144 Lombard St., Winnipeg, and 190 Braemar Ave., Norwood, Man., Canada.
- GODFREY, J. E.** (J 1938) General Foreman, Saginaw Steering Gear Div., General Motors Corp., and •1711 Cornell Rd. N.E., Atlanta, Ga.
- GOEHLER, Elmer E.** (A 1939) 1921 S.E. Grand Ave., Portland, Ore.
- GOELZ, Arnold H.** (M 1931) Pres., •Kroeschell Engineering Co., 215 W. Ontario St., Chicago, and 827 Greenwood Ave., Wilmette, Ill.
- GOERG, B.** (M 1928) American Radiator & Standard Sanitary Corp., 675 Bronx River Rd., Yonkers, N. Y.
- GOERGENSE, Albert G.** (A 1938) Engr., U. S. War Dept., Munitions Bldg., Washington, D. C., and •817 Chalfonte Dr., Alexandria, Va.
- GOFF, John A.*** (M 1939) Dean, •Towne Scientific School, University of Pennsylvania, Philadelphia, and 623 Righters Mill Rd., Narberth, Pa.
- GOINS, Edgar H.** (M 1941) Mfrs. Repr., •420 Market St., Room 204, and 2353 Laguna St., San Francisco, Calif.
- GOLDBERG, Moses** (A 1934) Pres., Electric Motors Corp., 168 Centre St., New York, and •885 E. Eighth St., Brooklyn, N. Y.
- GOLDMANN, Philipp** (J 1942; S 1940) Junior Engr., Carrier Corp., S. Geddes St., and •238 Fellows Ave., Syracuse, N. Y.
- GOLDSMITH, Elliot** (A 1942; J 1939) Engr., •Anemostat Corp. of America, 10 East 39th St., and 133 West 93rd St., New York, N. Y.
- GOLDSMITH, F. William** (M 1936) Pres., •The W. Clasmann Co., 513 E. Day Ave., and 629 E. Day Ave., Milwaukee, Wis.
- GOLL, Willard A.** (A 1937) U. S. Army Engr., 1709 Jackson, and •4353 Dodge St., Omaha, Nebr.
- GONZALEZ, Rafael A.** (M 1936) Capt., Ordnance Dept., U. S. Army, Tank Automotive Center, Union Guardian Bldg., and •Apt. 305, 300 Whitmore Rd., Detroit, Mich.
- GOOD, Charles S.** (J 1941; S 1939) Partner, A. C. Good & Sons, Pibg. & Htg., 620 Rebecca Ave., and •102 Cascade Rd., Wilkinsburg, Pa.
- GOODMAN, C. E.** (M 1940) Mgr., R. P. Allsop (Consulting Engr.) 1221 Bay St., Toronto, and •519 Cassells St., North Bay, Ont., Canada.
- GOODMAN, William** (M 1941) The Trane Co., and •211 North 23rd St., LaCrosse, Wis.
- GOODRAM, W. E.** (M 1939; A 1936) Partner and Mgr., Goodram Bros., 88 King St., W., Hamilton, and •R. R. 2, Freeman, Ont., Canada.
- GOODRICH, Charles F.** (M 1919) Andrews & Goodrich, Inc., Boston, and •336 Adams St., Dorchester, Mass.
- GOODWIN, Eugene W.** (M 1936) Principal Mech. Engr., Public Buildings Administration, F. W. A., Washington, D. C., and •7024 Hampden Lane, Bethesda, Md.
- GOODWIN, Samuel L.** (*Life Member*; M 1924) Consulting Engr., John & Drew Ebersson, 2 West 47th St., New York, N. Y., and •247 Madison Ave., Hasbrouck Heights, N. J.
- GORBANDT, Everett T.** (M 1941) Partner, •Crawley-Gorbandt Co., 118 W. Peachtree Pl. N.W., and 2288 N. Decatur Rd. N.E., Atlanta, Ga.
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- GORDON, Peter B.** (A 1938; J 1935) Treas., •Wolf & Munier, Inc., 222 East 41st St., New York, N. Y., and 35 Park Ave., Bloomfield, N. J.
- GORDON, William D.** (A 1935) Vice-Pres., •Canada Register & Grille Co., Ltd., 196 George St., and 174 Glen Cedar Rd., Toronto, Ont., Canada.
- GORGEN, Roy E.** (A 1940) Owner, •Roy E. Gorgen Co., Wesley Temple Bldg., Minneapolis, and 2901 Raleigh Ave., St. Louis Park, Minn.
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- GOSSETT, Earl J.** (M 1923) Pres., •Bell & Gossett Co., Morton Grove, and 314 Woodland Ave., Winnetka, Ill.
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- GOULD, James L.** (*J* 1942) Erection Supt. of Air Cond. Equipment, Cooke-Bain Air Cond. & Sheet Metal Contractors, Bomber Assembly Plant, Tulsa, Okla., and •1701 Poyntz Ave., Manhattan, Kan.
- GOULDING, William** (*A* 1933) Air Cond. Engr., World Broadcasting System, Inc., 711 Fifth Ave., New York, and •42 Highview Ave., Tuckahoe, N. Y.
- GROUNDIE, Joseph K.** (*M* 1938) Sales Engr., Fritch Coal Co., 116 River St., Bethlehem, and •1426 Walnut St., Allentown, Pa.
- GOWDY, Allen C.** (*A* 1941; *J* 1939) Contract Engr., The Huffman-Wolfe Co., 1800 U. B. Bldg., and •925 Meredith St., Dayton, Ohio.
- GRABER, Ernst** (*A* 1942; *J* 1936) Engr., Minneapolis-Honeywell Regulator Co., 221 Fourth Ave., New York, and •222 Hollywood Ave., Douglaston, L. I., N. Y.
- GRABMAN, Henry B.** (*J* 1942; *S* 1938) Lt., •95th Engr. Regt., A. P. O. 998, c/o Postmaster, Seattle, Wash., and 355 E. Spring St., Zelenople, Pa.
- GRAHAM, F. D.** (*M* 1940) Local Mgr., •York Ice Machinery Corp., 222 Union Bldg., and 4204 S. Broad, New Orleans, La.
- GRAHAM, William D.** (*M* 1929; *A* 1925; *J* 1923) Mgr., Unit Heater Dept., Carrier Corp., and •533 Allen St., Syracuse, N. Y.
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- GRAVES, Vernon** (*A* 1941; *J* 1940) Engr., Frank A. Leon Co., 901 Girard St. N.W., Washington, D. C.
- GRAY, Earle W.** (*M* 1938; *A* 1934) Div. Sales Mgr., •Oklahoma Gas & Electric Co., P. O. Box 1498, and 2125 Northwest 18th St., Oklahoma City, Okla.
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- GRAY, G. A.** (*M* 1924) Mgr., •C. A. Dunham Co., Ltd., 404 Plaza Bldg., 45 Rideau St., and 114 Belmont Ave., Ottawa, Ont., Canada.
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- GRAY, John W.** (*M* 1938) Owner, The Gray Heating Co., 614 N. Water St., Bay City, Mich.
- GRAY, William E.** (*M* 1922) Dehydration Engr., U. S. Dept. of Agriculture, Beltsville Research Center, Beltsville, and •Apt. 1-A, 4100 Russell Ave., Kaywood Gardens, Mt. Rainier, Md.
- GREEN, Everett W.** (*J* 1938) Pvt., Co. A. 87th Battalion, 3rd Platoon, U. S. Army, and •2747 North 48th, Lincoln, Neb.
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- GREENBURG, Leonard, M.D.*** (*M* 1932) Exec. Dir., Div. of Industrial Hygiene, •New York State Dept. of Labor, 80 Centre St., and 44 West 77th St., New York, N. Y.
- GREENLAND, Sidney F.** (*M* 1934) Htg. and Vtg. Engr., Messrs. J. Brockhouse & Co., Ltd., Victoria Works, West Bromwich, Staffs., and •75 Grestone Ave., Handsworth Wood, Birmingham 20, England.
- GREGG, Stephen L.** (*A* 1939; *J* 1936) Lt., U. S. N. R., and 4828 Edgemore Lane, Bethesda, Md.
- GREILING, Winford W.** (*M* 1942) Mech. Engr., Austin Co., c/o Chemical Warfare Plant, Midland, and •941 Collingwood Ave., Detroit, Mich.
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- GRIESS, Phillip G.** (*M* 1937) Mech. Engr., Voorhees, Walker, Foley & Smith, 101 Park Ave., New York, N. Y., and •189 Walnut Ave., Bogota, N. J.
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- GRIFFITH, Claude A.** (*A* 1938) Htg. and Vtg. Engr., Griffith Air Conditioning Service, 16 Altamont Terrace, Cumberland, Md.
- GRIFFITH, Herbert T.** (*M* 1938) Design Engr., •Lincoln Bouillon, Consulting Engr., 1411 Fourth Ave. Bldg., and 1909 Third Ave. W., Seattle, Wash.
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- GRITSCHKE, Elmer R.** (*M* 1940) Consulting Engr., •E. R. Gritschke, Consulting Engrs., 123 W. Madison St., Chicago, and 1432 Gregory Ave., Wilmette, Ill.
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- GROOT, Harry W.** (*M* 1937) Assoc. Engr., U. S. Navy Dept., Office of Asst. Suprv. of Shipbuilding, Evansville, Ind., and •3728 N. Western Pkwy., Louisville, Ky.
- GROSS, Lester** (*J* 1942) Constr. Supt., General Installation Co., 2234 Olive and •1368 Shawmut Pl., St. Louis, Mo.
- GROSS, Lyman C.** (*M* 1931) Sales Engr., Minneapolis-Honeywell Regulator Co., 2727 Fourth Ave. S., and •5324 Oaklawn Ave., Linden Hills Station, Minneapolis, Minn.
- GROSSENACHER, Henry E.** (*A* 1938) Pres., •Grossenbacher Furnace Co., Inc., 9416 W. Milton St., St. Louis Co., and 9741 Lackland Rd., Overland, Mo.
- GROSSMAN, F. Arthur** (*J* 1938; *S* 1937) Process Engr., Servel, Inc., and •867 S. Harlan Ave., Evansville, Ind.
- GROSSMANN, Harry A.** (*M* 1931) Owner, H. A. Grossmann Co., 3138 Case Ave., St. Louis, and •16 Huntleigh Downs, Route 5, Kirkwood, Mo.
- GROVES, Samuel A.** (*A* 1940; *J* 1935) Sales Suprv., American Radiator & Standard Sanitary Corp., 32-04 Northern Blvd., Long Island City, L. I., and •36 Cross St., Bronxville, N. Y.
- GUEST, P. L., Jr.** (*A* 1939) Mgr., •P. L. Guest Sales Co., 311 Piedmont Bldg., and 716 Dover Rd., Greensboro, N. C.

- GUEST, Ross B.** (A 1940) Estimator and Engr., • Guest & Viviano Sheet Metal Works, Inc., 827-37 Dryades St., and 1043 Peniston St., New Orleans, La.
- GUILBERT, Stanley R.** (A 1940) Air Cond. Engr., The Riester & Thesmacher Co., 1526 West 25th St., Cleveland, and • R. F. D. 3, Chagrin Falls, Ohio.
- GULER, George D.** (A 1937) Eastern Supvr., A. C. C. Div., Minneapolis-Honeywell Regulator Co., 221 Fourth Ave., New York, and • 6McBride Ave., White Plains, N. Y.
- GUMAER, P. Wilcox** (M 1937) Industrial Hygiene Engr., • The Barrett Co., 40 Rector St., New York, N. Y., and 25 Garden St., West Englewood, N. J.
- GUNTHER, Charles E.** (A 1941) Mgr., Htg. Dept., Campbell Coal Co., 240 Marietta St. N.W., and • 766 Flat Shoals Ave. S.E., Atlanta, Ga.
- GUNTON, Charles** (A 1941) Vice-Pres., Service Heating Equipment Co., 1913 Ingersoll, and • 1339-64th St., Windsor Heights, Des Moines, Iowa.
- GUNZEL, R. M.** (M 1930) Mfrs. Repr., • R. M. Gunzel & Co., 320 Crocker St., Los Angeles, and 375 La Mirada Ave., San Marino, Calif.
- GURNEY, E. Holt** (M 1929) (*Presidential Member*) (Pres., 1938; 1st Vice-Pres. 1937; 2nd Vice-Pres., 1936; Council, 1931-39) Pres., • The Gurney Foundry Co., Ltd., 4 Junction Rd., and 347 Walmer Rd., Toronto, Ont., Canada.
- GURNEY, Edward R.** (A 1940; J 1937) Asst. to Plant Supt., • The Gurney Foundry Co., Ltd., 4 Junction Rd., Toronto, Ont., and 2425 Fifth Ave., Three Rivers, Que., Canada.
- GUSTAFSON, Carl A.** (M 1938) Sales Engr., • The Powers Regulator Co., 2720 Greenview Ave., and 6231 Fairfield Ave., Chicago, Ill.
- GUTKNECHT, Fritz** (M 1940) Engr., • Blattmann Weesser Sheet Metal Works, Inc., 1001 Toulouse St., New Orleans, La., and R. F. D. No. 2, Gulfport, Miss.
- H**
- HAAS, Samuel L.** (M 1923) Pres.-Treas., • Advance Heating & Air Conditioning Corp., 117-119 N. Desplaines St., 4300 Lake Shore Dr., Chicago, Ill.
- HACH, Edward C.*** (M 1939) Chief of Production Unit, Tank Branch, • Pittsburgh Ordnance Dist., War Dept., Chamber of Commerce Bldg., Pittsburgh, and 221 Broadmoor Ave., Mt. Lebanon, Pa.
- HACKETT, Frank C.** (A 1940) Resident Mgr., Bell & Gossett Co., 4855 North 16th St., Arlington, Va.
- HADEN, G. Nelson** (M 1934; A 1928; J 1922) Chairman and Managing Dir., • G. N. Haden & Sons, Ltd., 19-29 Woburn Pl., and 36 Wildwood Rd., London, W. C. 1, England.
- HADEN, William N.** (*Life Member*; M 1902) Retired Chairman, G. N. Haden & Sons, Ltd., 19-29 Woburn Pl., London, W. C. 1, and • Arnolds Hill, Trowbridge, England.
- HADJISKY, Joseph N.** (M 1930) Consulting Engr., 744 Bates St., Birmingham, Mich.
- HAERLE, Robert A.** (A 1938) Design Engr., Bayley Blower Co., 1817 South 66th St., and • 1438 N. Humboldt Ave., Milwaukee, Wis.
- HAGAN, William V.** (M 1938; A 1933; J 1926) Secy., V. J. Hagan Co., 506 Pearl St., and • 1811 Jones St., Sioux City, Iowa.
- HAGEDON, Charles H.** (M 1919) Partner, • S. E. Fenstermaker & Co., 937 Architect and Builders Bldg., and 945 West 58th St., Indianapolis, Ind.
- HAHN, Roy F.** (A 1941; J 1936) Air Cond. Engr., Advance Refrigeration, Inc., 274 Eighth St. N.E., Atlanta, Ga.
- HAINES, John E.** (M 1940) Mgr. Air Cond. Controls Div., • Minneapolis-Honeywell Regulator Co., 2747 Fourth Ave. S., and 2119 Humboldt Ave. S., Minneapolis, Minn.
- HAINES, John J.** (M 1915) Pres., • The Haines Co., 1931 W. Lake St., Chicago, and 623-17th Ave., Maywood, Ill.
- HAITMANEK, Louis M.** (A 1938) Htg. and Vtg. Engr., 217 Rose St., Newark, N. J.
- HAKES, Leon M.** (M 1932; J 1929) Resident Repr., • Warren Webster & Co., 210 Reynolds Arcade Bldg., and 144 Inglewood Dr., Rochester, N. Y.
- HALE, Frederick J.** (M 1936) Mgr., • Empire Sheet Metal Works, Ltd., 1606 W. First Ave., Vancouver, and 995 Mathers Ave., W. Vancouver, B. C., Canada.
- HALEY, Harry S.*** (M 1914) Consulting Engr., and Partner, • Leland & Haley, 58 Sutter St., and 735-21st Ave., San Francisco, Calif.
- HALL, Cortice H.** (M 1927) Chief Engr., Stoker Div., • Fairbanks, Morse & Co., and 1004 N. Main St., Three Rivers, Mich.
- HALL, George** (A 1937) Secy.-Treas. and Mgr., • Hyland, Hall & Co., 218 N. Bassett St., 4201 Wanetah Trail, Nakoma, Madison, Wis.
- HALL, John R.** (M 1937; J 1932) Chief Engr., • Morrison Engineering Corp., 5005 Euclid Ave., Cleveland, and 17700 Fries Ave., Lakewood, Ohio.
- HALL, Mora S.** (M 1934) • Paul Rosenthal & Associates, 600 Newton Pl. N.W., Washington, D. C., and 38 and Utah, Brentwood, Md.
- HALL, Norman H.** (A 1939) Supvr. House Htg., • East Ohio Gas Co., East 62nd St., North of St. Clair, Cleveland, and 147 Beachview Rd., Willoughby, Ohio.
- HALLER, Arthur L.** (M 1920) Pres.-Treas., • Hayer Appliance Sales Co., Inc., 3903 Olive St., St. Louis, and 7485 Drexel Dr., University City, Mo.
- HAMACHER, K. F.** (M 1938) Partner • Hamacher & Williams, 2540 W. Wells St., and 4387 S. Austin Ave., Milwaukee, Wis.
- HAMIG, Louis L.** (M 1941; A 1940; J 1935) Engr., John D. Falvey, Consulting Engr., 316 N. Eighth St., and • 3514 Utah St., St. Louis, Mo.
- HAMILTON, Howard S.** (A 1940) Owner, Air Comfort Co., 1214 N. Astor St., Milwaukee, Wis.
- HAMILTON, M. S.** (M 1942) Dist. Mgr., Minneapolis-Honeywell Regulator Co., 405 Penn Ave., Pittsburgh, and • 80 Altadena Dr., Pittsburgh, (16) Pa.
- HAMLET, F. Aylmer** (A 1936) Branch Mgr. Sales Office, • C. A. Dunham Co., Ltd., Dominion Square Bldg., Room 832, 1010 St. Catherine St., and 3550 Shuter St., Montreal, Que., Canada.
- HAMLIN, James B., Jr.** (A 1937) 1st Lt., Corps of Engrs., U. S. Engineers Office, and 914 East 40th St., Savannah, Ga.
- HANBURGER, Fred W.** (M 1930) Consulting Engr., 252 West 76th St., New York, N. Y.
- HANLEIN, Joseph H.** (M 1937) Vice-Pres. and Treas., • Wilberding Co., Inc., 1822 Eye St. N.W., and 5420 Connecticut Ave. N.W., Washington, D. C.
- HANLEY, Edward V.** (A 1933) Pres., • S. V. Hanley Co., 1653 N. Farwell Ave., Milwaukee, and 844 E. Birch Ave., Whitefish Bay, Wis.
- HANLEY, T. F., Jr.** (M 1933) Pres., • Hanley & Co., 1503 S. Michigan Ave., and 1640 East 50th St., Chicago, Ill.
- HANNIGAN, William** (M 1940) Bldg. Supt., • Acacia Mutual Life Insurance Co., 51 Louisiana Ave., Washington, D. C., and Route 2, Silver Spring, Md.
- HANSEN, John T.** (A 1941) The Herman Nelson Corp., and • 1126-14th St., Moline, Ill.
- HANSLER, John E.** (M 1937) 723 Glen Ave., Westfield, N. J.
- HANSON, Leon C.** (A 1918) Secy.-Mgr., • Bjorkman Bros. Co., 712 Tenth St. S., and 4713 Townes Rd., Minneapolis, Minn.
- HANSON, Leslie P.** (M 1937; A 1936; J 1935; S 1933) Engr., U. S. Air Conditioning Corp., 2101 Kennedy N.E., and • 5027 Nokomis Ave. S., Minneapolis, Minn.
- HANTHORN, Walter** (A 1942; J 1939) Mech. Engr., Anacortes Shipways, Inc., and • 412-34th St., Anacortes, Wash.
- HARBERGER, G. L.** (A 1939) Mgr., Peerless Heating Div., The Eastern Foundry Co., Spring and Schaeffer Sts., Boyertown, and • 641 King St., Pottstown, Pa.

ROLL OF MEMBERSHIP

- HARBIN, Frank, Jr.** (M 1941) Htg. Engr., • Home Furnace Co., Sixth St. and P. M. Ry., and 181 West 21st St., Holland, Mich.
- HARBORDT, Otto E.** (A 1936) Sales Mgr., • U. S. Supply Co., 1315 West 12th St., and 4600 Mill Creek Pkwy., Kansas City, Mo.
- HARD, Amos L.** (A 1938) Chief Engr., Thos. Emery & Sons Co., Carew Tower, and •910 Kreis Lane, Cincinnati, Ohio.
- HARE, W. Almon** (M 1930) Executive Partner, Sawyer-Hare Furnace Co., 5736 Twelfth St., Detroit, Mich., and •833 Kildare Crescent, Windsor, Ont., Canada.
- HARDEN, J. Clinton** (M 1938) Engr., Round Oak Co., and •106 Courtland St., Dowagiac, Mich.
- HARDING, Edward R.** (M 1936) N. C. State Sales Engr., •Kewanee Boiler Corp., P. O. Box 536, 1003 Jefferson St. Bldg., Greensboro, and Guilford College, N. C.
- HARDING, Louis A.*** (*Life Member*; M 1911) (*Presidential Member*) (Pres., 1930; 1st Vice-Pres., 1929; 2nd Vice-Pres., 1928; Council, 1922-31) 85 Cleveland Ave., Buffalo, N. Y.
- HARDING, Walter** (M 1941) Supt. Engr., Air Ministry, N. E. Wing, Bush House, Kingsway, London, and •Danesfield House, 33 Bute Gardens, Wallington, Surrey, England.
- HARMONAY, William L.** (A 1935) Pres., •Michael Harmonay Corp., 124 Elm St., and 1346 Midland Ave., Yonkers, N. Y.
- HARRIGAN, Edward M.** (M 1915) Gen. Mgr., •Harrigan & Reid Co., 1365 Bagley Ave., and 7450 LaSalle Blvd., Detroit, Mich.
- HARRIGAN, Edward R.** (M 1939; J 1930) Sales Engr., Dist. Repr., •General Electric Co., 570 Lexington Ave., New York, N. Y., and 19 Erwin Pl., Caldwell, N. J.
- HARRINGTON, Elliott*** (M 1932; A 1930) In charge of Induction Sales, Industrial Dept., General Electric Co., Bldg., 2, Schenectady, N. Y.
- HARRINGTON, Larry J.** (M 1941) Partner, •Otto Schulz Plumbing & Heating Co., 2269 N.W. Northrup St., and 3530 S.E. Lambert St., Portland, Ore.
- HARRIS, Jesse B.** (M 1918) Co-Partner, •Rose & Harris, Engineers, 416 Essex Bldg., and 3620 Colfax Ave. S., Minneapolis, Minn.
- HARRIS, Warren S.*** (M 1942) Special Research Assoc., •University of Illinois, I-B-R. Research Home, 801 W. Green St., Urbana, and 1405 W. Park Ave., Champaign, Ill.
- HART, Harry M.*** (*Life Member*; M 1912) (*Presidential Member*) (Pres., 1916; 1st Vice-Pres., 1915; Council, 1914-17) Pres., •L. H. Prentice Co., 1048 Van Buren St., and 3730 Lakeshore Dr., Chicago, Ill.
- HART, John H.** (M 1942) Lt. (jg) U. S. N. R., •Naval Training School, Naval Architecture, M.I.T., Cambridge, and 365 Beacon St., Boston, Mass.
- HART, Stanley** (M 1938) Vice-Pres., Tuttle & Bailey, Inc., New Britain, Conn.
- HART, Theodore S.** (M 1938) Sales Mgr., Convector Div., Tuttle & Bailey, Inc., and •530 Lincoln St., New Britain, Conn.
- HARTIN, William R. Jr.** (J 1935) Asst. State Fuel Oil Director, O. P. A., Liberty Life Bldg.; Vice-Pres., Secy., W. R. Hartin & Son, Inc., and •2744 Trenholm Rd., Columbia, S. C.
- HARTMAN, John M.** (M 1927) Engr., •Kewanee Boiler Corp., and 618 Elliott St., Kewanee, Ill.
- HARTON, A. J.** (A 1935) Sales Engr., St. Joseph Railway, Light, Heat & Power Co., 520 Francis St., and •730 E. Hyde Park Ave., St. Joseph, Mo.
- HARTWEIN, C. E.** (M 1933) Supvr., House Heating and Service Div., •St. Louis County Gas Co., 231 W. Lockwood Ave., Webster Groves, and 135 Peeke Ave., Kirkwood, Mo.
- HARTWELL, Joseph C.** (M 1922) Pres. and Treas., •Hartwell Co., Inc., 87 Weybosset St., and 16 Freeman Parkway, Providence, R. I.
- HARVEY, Alexander D.** (A 1928; J 1925) Sales Mgr., •Kimberly-Clark Corp., and 819 E. Forest Ave., Neenah, Wis.
- HARVEY, John W.** (M 1942) Sales and Design Engr., York Shipley Ltd., London, N. W. 2, and •64 Crowshott Ave., Stanmore, Middlesex, England.
- HARVEY, Lyle C.** (M 1928) Pres., The Bryant Heater Co., 17825 St. Clair Ave., Cleveland, Ohio.
- HASHAGEN, John B.** (M 1930) Supt. of Production, Kingsbury Ordnance Plant, and •P. O. Box 274, La Porte, Ind.
- HASTINGS, Addison** (M 1942) Asst. Secy., Sales Engr., Burnham-Boiler Corp., and •Lewis Rd., Irvington, N. Y.
- HATCH, George** (A 1941) Pres., Air Conditioning Engineering Co., 1104 Bay St., and •Clarkson P. O., Ont., Canada.
- HATCH, Oscar J.** (A 1941) Mgr., •Clare Bros. Western, Ltd., 179 Notre Dame Ave. E., Winnipeg, and 114 Chestnut St., Winnipeg, Man., Canada.
- HATTIS, Robert E.** (M 1926) Consulting Engr., •Board of Trade Bldg., and 1454 W. Fargo Ave., Chicago, Ill.
- HAUAN, Merlin J.** (M 1933) Consulting Engr., 3412-16th St., Seattle, Wash.
- HAUER, Fred** (A 1938) Owner, Fred Hauer & Co., 315 Elmhurst Ave., Peoria, Ill.
- HAUS, Irvin J.** (A 1937; J 1935) Elec. Engr., Nash Kelvinator Corp., 3880 N. Richards St., and •5410 W. Center St., Milwaukee, Wis.
- HAUSMAN, Louis M.** (M 1935) Address Unknown—Mail Returned.
- HAUSS, Charles F.*** (*Life Member*; M 1922) Ball Heights, California, Ky.
- HAWES, Harold D.** (J 1942; S 1940) Lt., U. S. Army •Instructor A. A. School, A. A. S. O. C. D., Searchlight Dept., Camp Davis, N. C., and 454 Toilsome Hill Rd., Bridgeport, Conn.
- HAWISHER, Harold H.** (A 1938) Mech. Engr., •Automatic Heating & Engineering Co., 416 N. Main St., and 411 S. Jamison Ave., Lima, Ohio.
- HAYES, James J.** (M 1920) Vice-Pres., •Stannard Power Equipment Co., 53 W. Jackson Blvd., and 7443 Jeffery Ave., Chicago, Ill.
- HAYES, Joseph G.** (*Life Member*; M 1908) Pres. and Engr., •Hayes Brothers, Inc., 236 W. Vermont St., and 2849 N. Capital Ave., Indianapolis, Ind.
- HAYES, Orris J.** (S 1941) Student, University of Minnesota, and •2630 Irving Ave. N., Minneapolis, Minn.
- HAYMAN, A. Eugene, Jr.** (A 1941; J 1935; S 1930) Draftsman, Moody & Hutchison, Consulting Engrs., 1701 Architects Bldg., Philadelphia, Pa., and •2715 Washington St., Wilmington, Del.
- HAYNES, Charles V.** (*Life Member*; M 1917) (*Presidential Member*) (Pres., 1934; 1st Vice-Pres., 1933; 2nd Vice-Pres., 1932; Council, 1926-29; 1932-35) P. O. Box 26, Ardmore, Montgomery County, Pa.
- HAZLEHURST, H. D.** (A 1939) Serviceman, Southern California Gas Co., 810 S. Flower St., Los Angeles, and •130 E. Garvey Ave., El Monte, Calif.
- HAZLETT, T. Lyle, M.D.** (M 1938) Medical Dir., Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.
- HEAGERTY, William H.** (A 1923) Sales Engr., •1427 Eye St. N.W., and 5100 N. Capitol St., Washington, D. C.
- HEATH, William R.** (M 1931) Asst. Chief Engr., Buffalo Forge Co., 490 Broadway, and •119 Wingate Ave., Buffalo, N. Y.
- HEBLEY, Henry F.** (M 1934) Prod. Control Mgr., •Pittsburgh Coal Co., Office No. 3, Library, and 210 Jefferson Dr., Mt. Lebanon, Pittsburgh, Pa.
- HECHT, Frank H.** (M 1930) Sales Engr., •B. F. Sturtevant Co., 2635 Koppers Bldg., and 1467 Barnesdale St., Pittsburgh, Pa.
- HECKEL, Edmund P.** (M 1918) E. P. Heckel & Associates, 407 S. Dearborn St., Chicago, and •314 Cuttriss Pl., Park Ridge, Ill.

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- HECKEL, Edmund P., Jr.** (*J* 1941) Engr., • Buffalo Forge Co., 490 Broadway, and 226 Linwood Ave., Buffalo, N. Y.
- HEDEEN, Laurel E.** (*M* 1942; *A* 1941; *J* 1938) Consulting Engr., M. L. Todd & Associates, 1111 Independence Ave., and • 817 Kingsley, Waterloo, Iowa.
- HEDGES, H. Berkley** (*M* 1919) Mgr. Industrial Sales, • John J. Nesbitt, Inc., Holmesburg, Philadelphia, and 114 Waverly Rd., Wyncote, Pa.
- HEDLEY, Park S.** (*M* 1923) • Park S. Hedley Co., 361 Delaware Ave., Buffalo, and 31 Westgate Rd., Kenmore, N. Y.
- HEEBNER, Walter M.** (*M* 1922) Sales Engr., Warren Webster & Co., 20 Washington Pl., Newark, and • 282 Highwood Ave., Teaneck, N. J.
- HEIBEL, Walter E.** (*M* 1917) Dist. Mgr., • Aerofin Corp., 11 West 42nd St., New York, N. Y., and Old Greenwich, Conn.
- HEILMAN, Russell H.*** (*M* 1923) Sr. Industrial Fellow, • Mellon Institute, and 2303 Beechwood Blvd., Pittsburgh, Pa.
- HEINKEL, Charles E.** (*J* 1938) Branch Mgr., • Frane Co., 310 Postal Bldg., and 1956 N.W. Raleigh, Portland, Ore.
- HEISTERKAMP, Herbert W.** (*A* 1940; *J* 1937) Mgr., Dehumidifier Div., • Bryant Heater Co., 17825 St. Clair Ave., Cleveland, and 175 East 207th St., Euclid, Ohio.
- HELBURN, I. B.** (*M* 1929; *J* 1927) Junior Assoc., • Wyman Engineering, 1306 Chamber of Commerce Bldg., and 781 Clinton Springs, Cincinnati, Ohio.
- HELLER, Joseph A.** (*A* 1938) Sales, • Air Conditioning Utilities Co., 8 West 40th St., and 150 West 79th St., New York, N. Y.
- HELLMERS, Charles C., Jr.** (*A* 1942; *J* 1937) Engrg. Designer, Htg., Vtg., Air Cond., Sanderson and Porter, c/o Pine Bluff Ars., and • Box 303 (215 Beech), Pine Bluff, Ark.
- HELLSTROM, John** (*A* 1929) Vice-Pres., • American Air Filter Co., Inc., 215 Central Ave., and 423 Lightfoot Rd., Louisville, Ky.
- HELSTROM, Clifford W.** (*M* 1938) Sales Mgr., Globe Machinery & Supply Co., E. First and Court Ave., and • 1614 Thompson, Des Moines, Iowa.
- HELSTROM, Herman G.** (*M* 1928) Firebox Boiler and Stoker Div., William Bros. Boiler & Manufacturing Co., Niccollet Island, and • 4608 Arden Ave. S., Minneapolis, Minn.
- HELWICK, Numa John** (*M* 1940) Secy. and Mech. Engr., • American Heating & Plumbing Co., Inc., 829 Baronne St., and 809 Greenwood St., New Orleans, La.
- HENDERSON, Alexander S.** (*J* 1940; *S* 1938) Designing Engr., • S. F. (Australia) Pty. Ltd., Oswald Lane, Darlinghurst, N. S. W., and 65 Eastwood Ave., Eastwood, N. S. W., Australia.
- HENDRICKSON, Harold M.** (*M* 1934) Asst. Branch Engr., • York Ice Machinery Corp., 5051 Santa Fe Ave., Los Angeles, and 3901 Liberty Blvd., South Gate, Calif.
- HENDRICKSON, Ralph L.** (*M* 1938) 6125 Kenwood Ave., Chicago, Ill.
- HENDRICKSON, W. B.** (*A* 1940) Staff Sgt., Harlingen Army Gunnery School, Harlingen, Texas, and • c/o Miss Anna M. Hendrickson, 340 Carteret St., Camden, and 5 Sheffield Ave., Englewood, N. J.
- HENDRIKSEN, Leonard** (*A* 1938) Prop., Hendriksen Sheet Metal & Heating Service, 1919 Vernon Ave., Flint, Mich.
- HENION, Hudson D.** (*A* 1923) Sales Mgr., • C. A. Dunham Co., Ltd., 1523 Davenport Rd., and 45 Ridge Dr., Toronto, Ont., Canada.
- HENNESSY, William J.** (*M* 1938) Air Cond. Operation, U. S. Rubber Co., Munition Div., Des Moines Ordnance Plant, and • 1238-47th St., Des Moines, Iowa.
- HENRY, Alexander S., Jr.** (*M* 1930) Mech. Engr., R. K. O., 1270 Sixth Ave., and • 300 Central Park W., New York, N. Y.
- HENRY, Ernest C.** (*M* 1938) Owner, E. C. Henry Co., 1317 S. Water St., and • 1115 Park Ave., Bay City, Mich.
- HEPBURN, E. M.** (*A* 1940) Branch Mgr., • Empire Brass Manufacturing Co., Ltd., 74 Princess St., and 954 McMillan Ave., Winnipeg, Man., Canada.
- HERBERT, James S.** (*J* 1940) Sales Engr., • Blue Ridge Glass Corp., and 165 W. Sevier, Kingsport, Tenn.
- HERBERT, Richard M.** (*J* 1938) Lt., • U. S. Army Air Corps, Lubbock Army Flying School, and 2314 Sixth St., Lubbock, Texas.
- HERING, Alfred** (*M* 1935) Pres., Hering Heating Co., Inc., 130 Tenbroeck Ave., New York, N. Y.
- HERLIHY, Jeremiah J.** (*Life Member*; *M* 1914) 3751 Eddy St., Chicago, Ill.
- HERMAN, Neil B.** (*A* 1943; *J* 1937; *S* 1936) Engr., Riggs Distler & Co., Inc., 516 Fifth Ave., New York, N. Y., and • 4217 Garfield Ave. S., Minneapolis, Minn.
- HERMANN, Harold N.** (*M* 1942) Pres., • Carl J. Kiefer Associates, Inc., 26 E. Sixth St., and 3946 Ledgewood Dr., Cincinnati, Ohio.
- HERO, George A., Jr.** (*M* 1940) Lt.-Comdr., U. S. N. R., and • P. O. Box 13, Gretna, La.
- HERRE, Harold A.** (*J* 1941; *S* 1940) Ensign, Engineering Officer, U. S. S. Humphreys, Fleet Post Office, San Francisco, Calif.
- HERRING, Edgar** (*Life Member*; *M* 1919) Chairman and Governing Dir., • J. Jeffreys & Co., St. George's House, 195-203 Waterloo Rd., London, S. E. 1, and "Kenia," Keswick Rd., Putney, London, S.W., England.
- HERSH, Franklin C.** (*M* 1939; *A* 1933; *J* 1930) Tech. Engr., Pennsylvania Power & Light Co., 901 Hamilton St., and • 317 South 16th St., Allentown, Pa.
- HERSHEY, Albert E.*** (*M* 1940) Research Engr., Westinghouse Electric & Manufacturing Co., Research Laboratories, E. Pittsburgh, and • 10806 Frankstown Rd., Wilkinsburg, Pa.
- HERSKE, Arthur R.** (*M* 1928) Pres., Herske & Timmis, Inc., 33 West 60th St., New York, and • 101 Brookfield Rd., Mt. Vernon, N. Y.
- HERTY, Frank B.** (*M* 1933) Assoc. Engr., Office of District Engineer, U. S. Engr., and • 294 Congress St., Charleston, S. C.
- HERTZLER, John R.** (*M* 1936; *J* 1928) Lt., U. S. N. R., Army and Navy Munitions Board, Resources Division, Office of Procurement and Material, and • 1109-16th St., N.W., Washington, D. C.
- HESS, Arthur J.** (*M* 1937) Engr., • English & Lauer, Inc., 1978 S. Los Angeles St., Los Angeles, and 897 Linda Vista, Pasadena, Calif.
- HESELFSCHWERDT, August L., Jr.** (*M* 1940; *J* 1937) Asst. Prof., • Dept. of Mech. Engrg., Massachusetts Institute of Technology, Cambridge, and 28 Hillcrest Rd., East Milton, Mass.
- HESSLER, Lester W.** (*M* 1936) Mgr., The Trane Co., 1835 N. Third St., and • 6034 N. Bayridge Ave., Milwaukee, Wis.
- HESTER, Thomas J.** (*M* 1919) Pres., • Hester Bradley Co., 2835 Washington Ave., and 405 Washington Ave., St. Louis, Mo.
- HEWETT, John B.** (*M* 1937; *A* 1935) Sales Mgr., Anemostat Corp. of America, 10 East 39th St., New York, and • 130 Cochrane Ave., Hastings-on-Hudson, N. Y.
- HEYDON, Charles G.** (*A* 1923) Mgr., Sales of Western Div., Wright Austin Co., 315 W. Woodbridge St., and • 2081 Nebraska, Detroit, Mich.
- HEYMSFIELD, Herbert** (*M* 1941; *A* 1926) Automatic Htg. Instructor, Brooklyn Technical High School, and • 478 Third St., Brooklyn, N. Y.
- HICKEY, Daniel W.** (*A* 1931) Pres., • D. W. Hickey & Co., Inc., 1841 University Ave., and 1874 Highland Pkwy., St. Paul, Minn.
- HICKMAN, Herbert V.** (*A* 1938) Htg. Engr., • Neil H. Peterson Co., Mfrs. Repr., 1129 Folsom St., San Francisco, and 433 San Diego Ave., Daly City, Calif.

ROLL OF MEMBERSHIP

- HIERS, Charles R.** (M 1929; J 1927) Modine Manufacturing Co., 101 Park Ave., New York, and •19 Westminster Rd., Great Neck, L. I., N. Y.
- HIGH, John M.** (M 1940; A 1938) Mgr. Insulation Div., •The Ruberoid Co., 500 Fifth Ave., and 305 Lexington Ave., New York, N. Y.
- HILDER, Frederick L.** (M 1937) Chief Engr., Electric Furnace-Man, Inc., Emmaus, and •2604 Walnut St., Allentown, Pa.
- HILL, Charles F.** (A 1942; J 1936) 52 Grace St., Malden, Mass.
- HILL, Edward, Jr.** (A 1942; J 1939) Capt., U. S. Army, Camp Roberts, and •345-12th St., Paso Robles, Calif.
- HILL, E. Vernon, M.D.*** (M 1914; A 1912) (*Presidential Member*) (Pres., 1920; 1st Vice-Pres., 1919; 2nd Vice-Pres., 1918; Council, 1915-21) 6826 Newell Ave., Chicago, Ill.
- HILL, H. G.** (J 1938) Mgr., Furnace and Air Cond. Div., The Gurney Foundry Co., Ltd., 4 Junction Rd., and •7 Armadale Ave., Toronto, Ont., Canada.
- HILL, Harold H.** (M 1935) Asst. Mgr., Navy Equipment Div., •American Blower Corp., 438 Woodward Bldg., and 3002 Rodman St. N.W., Washington, D. C.
- HILL, Jared A.** (M 1938) Htg. and Air Cond. Engr., Pacific Gas & Electric Co., 245 Market St., San Francisco, and •715 Laurel Ave., Burlingame, Calif.
- HILL, Vaughn H.** (A 1943; J 1938) Mech. Engr., Board of Water & Electric Light Commissioners, and •2111 Colvin Court, Lansing, Mich.
- HILL, Walter W.** (J 1940) Engr., United Clay Products Co., 931 Investment Bldg., and •3415 Fessenden St. W., Washington, D. C.
- HILLS, Arthur H.** (M 1924) Mgr., •Sarco Canada, Ltd., 85 Richmond St. W., and 21 Nealon Ave., Toronto, Ont., Canada.
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- JOSEPHSON, Simon** (A 1942; J 1936) Supervising Engr., • Astor Plumbing & Heating Corp., 155 Quincy St., and 199 E. Second St., Brooklyn, N. Y.
- JOYCE, James J.** (A 1941) Branch Mgr., • The Powers Regulator Co., 208 Balter Bldg., and 2328 State St., New Orleans, La.
- JUERGENS, Walter A.** (A 1940) Sales Engr., • Walter A. Juergens, 802 Times Star Tower, and 1447 Aster Pl., Cincinnati, Ohio.
- JUNG, John S.** (M 1930; A 1923) Htg. and Piping Contractor and Htg. Engr., • 2409 W. Greenfield Ave., and 1516 S. Layton Blvd., Milwaukee, Wis.
- JUNKER, W. H.** (M 1936) Dir. of Engrg., Emery Industries, Inc., 4300 Carew Tower, Fifth and Vine Sts., and • 6068 Dryden Ave., Cincinnati, Ohio.

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- KAHN, Charles R., Jr.** (J 1939) Lt. (jg) U.S.N.R., Industrial Dept., • U. S. Navy Yard, Philadelphia, Pa., and 118 Wood Lane, Woodmere, L. I., N. Y.
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- KAJUK, Andrew E.** (M 1936) Engr., War Dept. O. Q. M. G. Engrg. Design, Washington, D. C., and • 1859 Grantham Rd., Cleveland, Ohio.
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- KAPPEL, George W. A.** (M 1921) Pres., Treas., • Camden Heating Co., 8 Market St., Camden, and 421 Maple Ave., Westmont, N. J.
- KARAKASHI, Theodore J.** (A 1940; J 1936) Engr. in Chief, Carrier Air Conditioning Dept., C. & A. Baker, Ltd., P. O. Box 468, Istanbul, Turkey.
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- KARLSON, Alfred F.** (M 1918) Parks-Cramer Co., P. O. Box 444, Fitchburg, Mass.
- KARLSTEEN, Gustav H.** (M 1935) Plant Engr., Dunlop Tire & Rubber Corp., Buffalo, and • Box 55, Route 1, Tonawanda, N. Y.
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- KAUFMAN, H. J.** (M 1937) Owner, H. J. Kaufman, Mfr. Chemical Dehydrating Apparatus, 13215 Roselawn Ave., Detroit, Mich.
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- KAYAN, Carl F.** (M 1942) Asst. Prof. Mech. Engrg., School of Engrg., • Columbia University, Morningside Heights, and 425 Riverside Dr., New York, N. Y.
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- KEENEY, Frank P.** (A 1915) Pres., • Keeney Publishing Co., 6 N. Michigan Ave., and 7059 S. Shore Dr., Chicago, Ill.
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- KELBLE, F. R.** (M 1928) Vice-Pres., Mgr., • Hoffman-Wolfe Co. of Philadelphia, 4660 North 18th St., Philadelphia, and 205 Pleasant Ave., Glenside Gardens, Pa.
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- KELLY, Charles J.** (M 1931) New York Repr., • James P. Marsh Corp., 155 East 44th St., New York, N. Y., and 440 Fairmount Ave., Jersey City, N. J.
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- KELLY, Wilbur C.** (M 1935) Field Engr., • Iron Fireman Manufacturing Co. of Canada, Ltd., 602 King St. W., and 58 Elmsthorpe Ave., Toronto, Ont., Canada.
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- KENT, Laurence F.** (A 1927; J 1924) Pres., • Moncreff Furnace Co., P. O. Box 1673, and 1515 Morningside Dr. N.E., Atlanta, Ga.
- KENT, Richard L.** (M 1936) Dist. Mgr., • Trane Co. of Canada, Ltd., 303 New Hargrave Bldg., Hargrave St., and 147 Wellington Crescent, Winnipeg, Man., Canada.
- KEPLER, Donald A.** (J 1936; S 1934) Chief Engr., • New York Stock Exchange Building Co., 20 Broad St., New York, and 188 East 12th St., Huntington Station, L. I., N. Y.
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- KERN, Raymond T.** (M 1927) Chief Engr., Jennison Co., 17 Putnam St., Fitchburg, and • 51 Claflin St., Leominster, Mass.
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- KEYSER, Herman M.** (A 1937) Sales Engr., Murray W. Sales & Co., 801 W. Baltimore, Detroit, and • 10703 Hart, Huntington Woods, Royal Oak, Mich.
- KICZALES, Maurice D.** (M 1935) Chief Mech. Engr., U. S. Army Motion Picture Service, 400 Tower Bldg., and • 6200-31st St. N.W., Washington, D. C.
- KIDD, Charles R.** (M 1942; A 1938) Mech. Engr., Federal Public Housing Authority, Const. Div., Room 813, Longfellow Bldg., and • 54 V St. N.W., Washington, D. C.
- KIEFER, E. J.** (A 1932; J 1928) Mgr., • H. C. Archibald Co., 406 Main St., and 108 N. Sixth St., Stroudsburg, Pa.
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- KILLIAN, William J.** (A 1940) Products Application Engr., The Herman Nelson Corp., 831 Temple Bar Bldg., and • 7519 Kirtley Dr., Kenwood, Cincinnati, Ohio.
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- KIMBALL, Charles W.** (M 1915) Pres.-Treas., and Richard D. Kimball Co., 6 Beacon St., Boston, and 65 Prescott St., West Medford, Mass.

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- KIMBALL, Dwight D.** (*Presidential Member*) (*Life Member*; *M* 1908) (Pres., 1915; 2nd Vice-Pres., 1914; Board of Governors, 1912-13; Council, 1914-16), Consulting Engr., •1728 Grand Central Terminal Bldg., and 145 West 58th St., New York, N. Y.
- KIMBLE, Carl W.** (*A* 1943; *J* 1938) Owner-Partner, •Advance Heating & Sheet Metal Works, 315-24th St., and 2020-38th St., Rock Island, Ill.
- KIMMELL, Phillip M.** (*M* 1942; *J* 1936) Mech. Engr., •Eastman Kodak Co., Hawk Eye Works, and 33 Stonecliff Dr., Rochester, N. Y.
- KING, Arthur C.** (*M* 1936) Consulting Engr., 35 S. Dearborn St., Chicago, Ill.
- KING, John S.** (*A* 1940) Combustion Engr., •Anthracite Industries Laboratory, Primos, and Green Lane and Ashland Ave., Secane, Pa.
- KINGSLAND, George D.** (*M* 1935) R. R. No. 3, Eureka, Mo.
- KINGSWELL, William E.** (*M* 1935) Pres., •William E. Kingswell, Inc., 3707 Georgia Ave. N.W., Washington, D. C., and R. F. D. 1, Silver Spring, Md.
- KINNEY, Aldon M.** (*M* 1936) Pres., •A. M. Kinney, Inc., Consulting Engrs., 1301-6 Enquirer Bldg., and Indian Hill, Cincinnati, Ohio.
- KIPE, J. Morgan** (*M* 1919) Dir. of Education, Anthracite Industries, Inc., 2204 Walnut St., Philadelphia, and 801 Homestead Ave., Beechwood, Upper Darby, P. O., Pa.
- KIRKBRIDE, J. Owen** (*M* 1938) Partner, Parent & Kirkbride, •N. W. Corner Fourth and Locust Sts., Philadelphia, Pa., and 1121 Eldridge Ave., West Collingswood, N. J.
- KIRKENDALL, Horton J.** (*M* 1942; *A* 1938) Sales Repr., Htg. Equipment, 291 Catalpa Pl., Pittsburgh, (16), Pa.
- KIRKPATRICK, Arthur H.** (*M* 1935; *J* 1931) Dist. Sales Mgr. and Engr., •Ilg Electric Ventilating Co., 415 Brainard St., and Hotel Webster Hall, Detroit, Mich.
- KIRTLAND, Eugene M.** (*A* 1940) Pres., •Engineering Specialty Co., 204 W. Ridge Rd., and 2900 W. Beverly Dr., Gary, Ind.
- KITCH, Richard B.** (*M* 1941) Registered Engr., •Mfrs. Repr., 314 Palmer Bldg., and Rte. 2, N. Druid Hills Rd., Atlanta, Ga.
- KITCHEN, Francis A.** (*A* 1927; *J* 1923) Pres., •American Warming & Ventilating Co., 1514 Prospect Ave., Cleveland, and 2077 Campus Rd., South Euclid, Ohio.
- KITCHEN, John H.** (*Life Member*; *M* 1906) Pres., Mgr., •John H. Kitchen & Co., 1016 Baltimore Ave., and 5015 Westwood Terrace, Kansas City, Mo.
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- KLAGES, Frank E. P.** (*M* 1940) Dist. Mgr., The Powers Regulator Co., 1034 Jefferson Standard Bldg., Greensboro, N. C.
- KLEIN, Edward W.** (*M* 1917) Repr., Warren Webster & Co., 152 Nassau St., N.W., and 456 Peachtree Battle Ave., Atlanta, Ga.
- KLEINKAUF, Henry** (*M* 1938; *J* 1937) Mgr., Natkin & Co., 506 South 18th St., Omaha, Nebr.
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- KLIEFOTH, Max H.** (*A* 1939) Treas., Research Products Corp., E. Washington Ave., Madison, Wis.
- KLINK, Erwin J.** (*J* 1942) Mech. Engr., Johnson Service Co., 230 E. Alexandrine, Detroit, Mich.
- KLUCKHUHN, Frederick H.** (*J* 1940) Mech. Engr., U. S. Navy Dept., 18th and Constitution Ave., Washington, D. C., and •1110 Montgomery Ave., Laurel, Md.
- KLUGE, Burnett M.** (*J* 1938) Sales Engr., Bayley Blower Co., 1817 South 66th St., and •1236 South 46th St., Milwaukee, Wis.
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- KNEPPER, H. H.** (*A* 1938) 1701 West 16th St., Texarkana, Texas.
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- KNOWLES, Frank R.** (*A* 1938) Dir. Commercial Engrg., •Pennsylvania Electric Co., 535 Vine St., and R. D. 4, Box 428, Johnstown, Pa.
- KNOX, John C.** (*A* 1938) Secy.-Treas., •Waterloo Register Co., 600 Anita St., and 176 Gates St., Waterloo, Iowa.
- KOCH, Albert H.** (*M* 1938) Regional Mgr., Minneapolis-Honeywell Regulator Co., 101 Marietta Bldg., and •3687 Peachtree Rd., Atlanta, Ga.
- KOCH, Richard G.** (*A* 1935) House Heating Engr., •Milwaukee Gas Light Co., 626 E. Wisconsin Ave., and 5707 W. Brooklyn Pl., Milwaukee, Wis.
- KOEHLER, C. Stewart** (*A* 1936) Sales Engr., Minneapolis-Honeywell Regulator Co., 221 Fourth Ave., and •4374 Richardson Ave., New York, N. Y.
- KOENIG, Andrew C.** (*J* 1940) Sales Engr., 701 E. Missouri St., Evansville, Ind.
- KOLAKOSKI, Roman** (*A* 1942) Owner and Mgr., Clarendon Plumbing & Heating Co., 4845-25th Rd. N., Arlington, Va.
- KOLASA, Marion J.** (*J* 1942) Engr., Gar Wood Industries, Htg. Div., 7924 Riopelle, and •2663 Frederick, Detroit, Mich.
- KOLB, Fred W.** (*M* 1938) •598 Monadnock Bldg., and 82 Macondray St., San Francisco, Calif.
- KOLB, Robert P.** (*M* 1939) Lt.-Comdr., U.S.N.R., •Postgraduate School, U. S. Naval Academy, Annapolis, Md., and 215 May St., Worcester, Mass.
- KOLLAS, Will J.** (*M* 1939) Chief Engr., Montag Stove & Furnace Works, 2011 N. Columbia Blvd., and •6104 N. Missouri Ave., Portland, Ore.
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- KRAPOHL, William H.** (*M* 1941) Sr. Engr. (Htg.) U. S. Government, 31 St. James Ave., Boston, and •79 Prospect St., W. Roxbury, Mass.
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- KRIBS, Charles L., Jr.** (*M* 1935) Mech. Engr., Lone Star Ordnance Plant, Texarkana, Texas, and •416 E. Fourth St., Apt. 3, Texarkana, Ark., and 3416 Drexel Ave., Dallas, Texas.
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- LAWRENCE, Floyd D.** (A 1938) Sales Engr., •Clarage Fan Co., 500 Fifth Ave., New York, and 34-31-81st St., Jackson Heights, L. I., N. Y.
- LAWRENCE, L. Frank, Jr.** (M 1942; J 1938) Branch Mgr., •Minneapolis-Honeywell Regulator Co., 304-101 Marietta St. Bldg., and 796 Amsterdam Ave. N.E., Atlanta, Ga.
- LEE, Burton H.** (A 1940) Htg. and Vtg. Engr., H. and V. Design •Giffels & Vallet, Inc., Consulting Engrs., Naval Operating Base, Norfolk, and 34th St., and Holly Rd., Virginia Beach, Va.
- LEE, James A.** (A 1937) Mgr. Contract Dept., Kelvinator Div., Nash-Kelvinator Corp., 14250 Plymouth Rd., Detroit, and •9912 Hubbard, Rosedale Gardens, Plymouth, Mich.
- LEE, Robert J.** (M 1941) Engr., The Ballinger Co., 105 South 12th St., and •2356-77th Ave., Philadelphia, Pa.
- LEE, Robert T.** (J 1937; S 1936) Engr. in charge, Charlotte War Products Pool, P. O. Box No. 59, and •2405 Shenandoah Ave., Charlotte, N. C.
- LEEK, Charles W.** (M 1938) Managing Dir., Leek & Co., Ltd., 1111 Homer St., and •4682 W. Sixth Ave., Vancouver, B. C., Canada.
- LEEK, Walter** (Life Member; M 1903) Pres., •Leek & Co., Ltd., 1111 Homer St., and 4763 W. Second Ave., Vancouver, B. C., Canada.
- LEFEVRE, Eugene J.** (M 1937) Engr., Warden King, Ltd., 2104 Bennett Ave., Montreal, and •378 Wood Ave., Westmount, Que., Canada.
- LEFFEL, Paul C.** (A 1941) Owner, The Leffel Co., 3323 Main, and •316 East 75th St., Kansas City, Mo.
- LEGLER, Frederick W.** (M 1935; A 1933) Pres., The Waterbury Co., 17 West 28th St., and •2919 Johnson St. N.E., Minneapolis, Minn.
- LEHMAN, John L.** (M 1942) Sales Engr., Columbia Radiator Co. & Triplex Heating Specialty Co., 12 Pittsfield St., Cranford, N. J.
- LEHMAN, M. G.** (A 1937) Owner, •720 O St., and 2011 Worthington, Lincoln, Nebr.
- LEICHNITZ, Robert W.** (J 1936) Mechanic, U. S. Navy, Puget Sound Navy Yard, Bremerton, and •203 Belmont N., Seattle, Wash.
- LEILICH, Roger L.** (M 1922) Pres., •The Wallace Stebbins Co., 100 S. Charles St., and Ruxton, Baltimore Co., Md.
- LEINBERGER, Richard J. P.** (J 1942) Albert Kahn Co., 345 New Centre Bldg., and •114 Pallister W., Detroit, Mich.
- LEINROTH, J. P.** (M 1929) Gen. Industrial Fuel Repr., Public Service Electric & Gas Co., 80-Park Pl., Newark, N. J.
- LEITCH, Arthur S.** (M 1908) Pres. and Managing Dir., The Arthur S. Leitch Co., Ltd., 1123 Bay St., and •421 Russell Hill Rd., Toronto, Ont., Canada.
- LEITGABEL, Kenneth A.** (J 1941; S 1939) Test Engr., Pratt & Whitney Aircraft, E. Hartford, and •Apt. 9, 95 W. Mid. Turnpike, Manchester, Conn.
- LELAND, Warren B.** (M 1929) Sales Engr., •The H. B. Smith Co., Inc., 57 Main St., Westfield, and 159 Sumner Ave., Springfield, Mass.
- LELAND, William E.** (Life Member; M 1915) Partner, •Leland & Haley, 58 Sutter St., San Francisco, and 704 The Alameda, Berkeley, Calif.
- LENIHAN, William O.** (A 1936) Vice-Pres., •Laverack & Haines, Inc., White Bldg., and 703 W. Ferry St., Buffalo, N. Y.
- LENONE, Jose M.** (M 1919) Lt.-Col., Corps of Engrs., and •1017 East 46th St., Chicago, Ill.
- LEONARD, Lorcan C. G.** (J 1937) Tech. Mgr., •McCann Jeffreys, Ltd., 19-20 Ellis Quay, Dublin, and 265 Clontarf Rd., Dollymount, Dublin, Ireland.
- LEONARD, R. R.** (A 1942; J 1941) Sales Engr., •A. M. Byers Co., 1409 Girard Trust Bldg., Philadelphia, Pa.
- LEONHARD, Lee W.** (M 1936) Asst. Supt., Eastman Kodak Co., and •1075 Winona Blvd., Rochester, N. Y.
- LEOPOLD, Charles S.** (M 1934) Consulting Engr., •213 S. Broad St., Philadelphia, and 7600 West Ave., Elkins Park, Pa.
- LeRICHE, Raymond E.** (A 1941) Dist. Office, Minneapolis-Honeywell Regulator Co., 2210 Second Ave., and •6345-39th S.W., Seattle, Wash.
- LESER, Frederick A.** (M 1941; A 1937) Dist. Mgr., •Ilg Electric Ventilating Co., 608 Mills Bldg., Washington, D. C., and 7201 Cobalt Rd., Wood Acres, Md.
- LESSINGER, Edgar F.** (A 1941) Mgr., •Lessinger Plumbing & Heating Co., 221 S. Tenth St., and 814 North 18th St., Boise, Idaho.
- LEUPOLD, George L.** (A 1937) Sales Engr., Minneapolis-Honeywell Regulator Co., 561 Reading Rd., and •1630 Northwood Dr., Cincinnati, Ohio.
- LEUTHESER, Fred W., Jr.** (M 1937) Secy., •National Metal Products Corp., 21 N. Loomis St., Chicago, and 1715 North 77th Court, Elmwood Park, Ill.
- LEVINE, Charles** (A 1943; J 1939) Air Cond. Service Engr., Alfred L. Hart, Inc., 938 Bergen St., and •1171 Ocean Pkwy., Brooklyn, N. Y.
- LEVINE, Lawrence J.** (J 1940) Ensign, U. S. Navy, and •1378 East 12th St., Brooklyn, N. Y.
- LEVITT, Leroy L.** (A 1942; J 1940) Lt. (jg), U. S. N. R., and •3326 Gwynns Falls Pkwy., Baltimore, Md.
- LEVY, Marion I.** (M 1938; A 1936; J 1931) Pres., •Viking Air Conditioning Corp., 5606 Walworth Ave., and 3156 Ludlow Rd., Cleveland, Ohio.
- LEWIS, Carroll E.** (M 1930) Sales Mgr., Delco-Appliance Div., General Motors Sales Corp., 391 Lyell Ave., and •9 Shelwood Rd., Rochester, N. Y.
- LEWIS, Harry E.** (A 1942; J 1939) •Owens-Corning Fiberglass Corp., Nicholas Bldg., and 1506 Potomac Dr., Toledo, Ohio.
- LEWIS, H. Frederick** (M 1940; A 1937) Vice-Pres. and Gen. Mgr., •Harvey A. Dwight Oil Heat & Supply Co., Inc., 147 Dongan Ave., Albany, and Sweet's Crossing, Nassau, N. Y.
- LEWIS, L. Logan*** (M 1918) Vice-Pres. and Chief Engr., •Carrier Corp., S. Geddes St., and 207 Sedgwick Dr., Syracuse, N. Y.
- LEWIS, Samuel R.*** (Life Member; M 1905) (Presidential Member) (Pres., 1914; 2nd Vice-Pres., 1910; Board of Governors, 1909-12; Council, 1914-15) Consulting Mech. Engr., •407 S. Dearborn St., and 4737 Kimbark Ave., Chicago, Ill.
- LEWIS, Thornton** (M 1919) (Presidential Member) (Pres., 1929; 1st Vice-Pres., 1928; 2nd Vice-Pres., 1927; Council, 1923-30) Deputy Chief, Production Service Branch, U. S. Army Ordnance Dept., Pentagon Bldg., and •2123 California St., Washington, D. C.
- LEWIS, W. Warner** (A 1939) Mgr. Refrig. and Air Cond., •Major Appliance Dept., Beeson Hardware Co., P. O. Box 1390, and 604 Woodrow Ave., High Point, N. C.
- LEY, Ralph B.** (A 1940) Assoc. Engr., War Dept., Washington, D. C., and •916 Park Ave., Falls Church, Va.
- LIBBY, Ralph S.** (A 1939; J 1933) Sales Engr., Sheldons, Ltd., 96 Grand Ave. S., and •34 Elliott St., Galt, Ont., Canada.
- LICANDRO, James F.** (A 1943; J 1938) Air Cond. Engr., •Carrier Corp., 1200 Statler Bldg., Boston, and 40 Elm St., Stoneham, Mass.
- LICHTY, C. P.** (Life Member; M 1920) Mgr., C. P. Lichty Engineering Co., 1120 W. Main St., Durham, N. C.
- LIEBLICH, Murray** (J 1943; S 1940) Ensign, U. S. N. R., P. O. Box 541, Hamilton, N. Y.
- LIFTON, David** (J 1942; S 1939) Inspector, Engineering Materials, Navy Department, and •2902 Webster Ave., Pittsburgh, Pa.
- LIGE, Walter W.** (M 1941; A 1940) Production Mgr., •Bell & Gossett Co., 8200 N. Austin Ave., Morton Grove, and 1031 Ash St., Winnetka, Ill.
- LIGHT, John C.** (A 1938) Capt., Ordnance Dept., Milan Ordnance Depot, Milan, Tenn., and •3004 Alamogordo St., El Paso, Texas.
- LIGHTHART, Charles H.** (M 1935) Mfrs. Sales Engr., •P. O. Box 112, Niagara Square Station, Buffalo, and Eden, N. Y.

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- LILJA, Oscar L.** (A 1937; J 1936) Htg. and Vent. Engr., Plant Engrg. Dept., Northwest Airlines, Inc., 1885 University Ave., St. Paul, and •5000 16th Ave. S., Minneapolis, Minn.
- LINCOLN, Roland L.** (M 1935) Mgr., Dust Lab., B. F. Sturtevant Co., Hyde Park, Boston, and •Dover, Mass.
- LINDSAY, Griffith W., Jr.** (M 1937) Supt. of Moulding, Kurz-Kasch, Inc., 1421 S. Broadway, and •301 N. Garland Ave., Dayton, Ohio.
- LINDSTROM, Donald F.** (J 1941) Assoc. Engr., Alvin L. Lindstrom, Consulting Mech. Engr., 1013 Mortgage Guarantee Bldg., Atlanta, and •451 Ansley St., Decatur, Ga.
- LINGEN, Ralph A.** (A 1939; J 1938) Dist. Mgr., •American Foundry & Furnace Co., 709 North 11th St., Milwaukee, and 6028 W. Wisconsin Ave., Wauwatosa, Wis.
- LINK, Charles H.** (S 1941) 607½ W. Franklin St., Jackson, Mich.
- LINSENMEYER, Francis J.** (M 1935) Dir. of Mech. Engrg., •University of Detroit, McNichols and Livernois, and 19020 Warrington Dr., Detroit, Mich.
- LINSKIE, George A.** (J 1939) War Dept., U. S. Engineers, Denison Dist., and •P. O. Box 495, Denison, Texas.
- LINTON, John P.** (M 1927) Pres., Engineering Installations, Ltd., 1154 Beaver Hall Sq., and •247 Brock Ave. N., Montreal W. Que., Canada.
- LIPSCOMBE, Harold W. J.** (M 1938) Mgr., Air Cond. Dept., Davidson & Co., Ltd., Central House, Kingsway, London, and •Glenmore, Woodland Way, West Wickham, Kent, England.
- LITTLEFORD, Wallace H.** (M 1936) Vice-Pres., •E. J. Febrey & Co., Inc., 616 New York Ave. N.E., Washington, D. C., and 4208 Edmonstone Ave., Hyattsville, Md.
- LIVELY, George P.** (M 1942) Sr. Engr. (Naval Arch.), U. S. Navy, Bureau of Ships, Washington, D. C., and •4006 Fifth St. N., Arlington, Va.
- LIVERMORE, James N.** (M 1939) Mech. Engr., •The Detroit Edison Co., 2000 Second Ave., Detroit, and Hanover Rd., Pleasant Ridge, Mich.
- LLOYD, Edmund H.** (A 1943; J 1936) 1st Lt. (Chief, Domestic Plants Unit), U. S. Army, Office, Chief of Engrs., Constr. Div. R. & U. Branch, and •3215 Newark St. N.W., Washington, D. C.
- LLOYD, Edward C.** (M 1927) Armstrong Cork Co., and •R. D. 5, Old Philadelphia Pike, Lancaster, Pa.
- LOBSTEIN, Melville G.** (M 1941) Chief Engr. in charge of Bldg. Exhibits, and Equip., Museum of Science and Industry, 57th St. and Lake Michigan, Chicago, and •1401 S. Highland Ave., Berwyn, Ill.
- LOCHMAN, Edward W.** (M 1942) Owner, •Edward W. Lochman Co., 1421 Cherry St., and 634 East 73rd Terrace, Kansas City, Mo.
- LOCK, Rowland H.** (M 1939) Vice-Pres., J. H. Lock & Sons, Ltd., 221 Sterling Rd., and •24 Kennedy Park Rd., Toronto, Ont., Canada.
- LOCKE, James S.** (M 1939) Sales Engr., Minneapolis-Honeywell Regulator Co., 433 E. Erie St., Chicago, and •1828 Fairview Ave. S., Park Ridge, Ill.
- LOCKE, Robert A.** (M 1935) Lt.-Comdr., U. S. N. R., and •Middletown, Pa.
- LOCKHART, Harold A.** (A 1936; J 1935) Chief Engr., Bell & Gossett Co., 8200 Austin Ave., Morton Grove, and •Box 5385 R. R. 7, Des Plaines, Ill.
- LOEFFLER, Frank X., Sr.** (M 1914) Pres., •Loeffler-Greene Supply Co., 1604 N. W. Fifth St., and 1811 Northwest 19th St., Oklahoma City, Okla.
- LONDON, Maurice** (A 1941) Owner, •S. & L. Engineering Co., 3006 Mermaid Ave., and 2926 Mermaid Ave., Brooklyn, N. Y.
- LONG, Edward J.** (J 1942; S 1939) Chief Plumb-ing Engr., Olsen, Dietrick, Carr & J. E. Greiner Co., Marine Air Station, and •P. O. Box 347, Edenton, N. C.
- LONG, Wayne E.** (M 1935) Capt., Signal Corps, U. S. Army, 800th Sig. Ser. Regt., Camp Crowder, Mo., and Texas Agricultural & Mechanical College, College Station, Texas.
- LONGCOY, Grant B.** (M 1933) Engr., Joseph Breslove, Consulting Engr., Leader Bldg., Cleveland, and •1215 Ramona Ave., Lakewood, Ohio.
- LOO, Ping Yok** (M 1933) Address Unknown—Mail Returned.
- LOUCKS, D. W.** (A 1930) Supvr., Industrial Elec. and Steam Sales, •Duquesne Light Co., 435 Sixth Ave., and 1049 Osage Dr., Wilkinsburg, Pittsburgh, Pa.
- LOUGHRAN, Patrick H., Jr.** (J 1937) Asst. Mgr. Govt. Sales Dept., Washington Gas Light Co., 1100 H St. N.W., and •4513-49th St. N.W., Washington, D. C.
- LOVE, Clarence H.** (M 1919) Mfrs. Agent, Nash Engineering Co., 421 Chamber of Commerce, and •16 Lexington Ave., Apt. 1A, Buffalo, N. Y.
- LOWE, Robert A.** (J 1938) Engr., United States Government, and •1206 Longwood, Los Angeles, Calif.
- LOWNSBERY, B. F.** (M 1920) Project Engr., Benjamin F. Shaw Co., 201 E. Lombard St., and •21 S. Sycamore St., Wilmington, Del.
- LUCK, Alexander W.** (Life Member; M 1919) Htg. Engr., Consultant, 532 Woodward St., Reading, and •2235 Fairview Ave., Mt. Penn, Reading, Pa.
- LUCKE, Charles E.** (M 1924) Stevens Prof. Emeritus Mech. Engrg., •Columbia University, Pupin Bldg., and 186 Riverside Dr., New York, N. Y.
- LUDLOW, Harold M.** (M 1940) Sales and Engrg., •H. M. Ludlow, 328 W. Capitol St., and 950 Pecan Blvd., Jackson, Miss.
- LUDWIG, Willis D.** (M 1942) Contract Engr., •York Ice Machinery Corp., P. O. Box 2210, Atlanta, and 143 Kings Highway, Decatur, Ga.
- LUND, Clarence E.*** (M 1936; J 1935; S 1933) Asst. Dir. and Assoc. Prof., University of Minnesota, Engineering Experiment Station, Experiment Engineering Bldg., and •4817-12th Ave. S., Minneapolis, Minn.
- LUTY, Donald J.** (M 1933) Chief Research Engr., Air Cond. Div., •Gar Wood Industries, Inc., 7924 Riopelle St., and 30 Colorado Ave., Detroit, Mich.
- LYFORD, Robert G.** (J 1939) Branch Mgr., •The Powers Regulator Co., 602 N. Akard, and 2717 E. Amherst Ave., Dallas, Texas.
- LYMAN, Samuel E.** (A 1924) Buensod-Stacey Air Conditioning, Inc., 60 East 42nd St., New York, N. Y., and •865 Hueston St., Union, N. J.
- LYNCH, James R.** (A 1940) Owner, •Lynch Furnace Co., 1804 N.E. Union, and 2952 N.E. Edgehill Pl., Portland, Ore.
- LYNCH, William L.** (M 1928) Pres., •Rome-Turney Radiator Co., and 1205 N. George St., Rome, N. Y.
- LYNN, Frederick E.** (M 1938) Refrig. Engr., Electric Products Corp., 5624 Penn Ave., Pittsburgh, and •312 Moyhend St., Springdale, Pa.
- LYON, Douglas McClure** (A 1941) Owner, Douglas McClure Lyon, 317 State Tower Bldg., and •c/o Harold Stone, 213 Highland Ave., Syracuse, N. Y.
- LYON, P. S.** (M 1929) Pres., •Cochrane Corp., 17th St. and Allegheny Ave., and 3416 Warden Dr., Philadelphia, Pa.
- LYONS, Cornelius J.** (A 1932) Sales Engr., •Nash Engineering Co., Wilson Ave., and 5 Olmstead Pl., S. Norwalk, Conn.

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- MABLEY, Louis C.** (M 1937) Lt., U. S. N. R., Commanding Officer of the U. S. S. C. 763, and •57 Meadow Lane, Grosse Pointe Farms, Mich.
- MABLEY, T. Hollister** (M 1939) Chief Engr., •Mechanical Heat & Cold, Inc., 7704 Woodward Ave., Detroit, and 2323 Yorkshire Rd., Birmingham, Mich.

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- MABON, James E.** (*J* 1942; *S* 1939) Engr., The Glenn L. Martin Co., 409 Southway, and •103 East 33rd St., Baltimore, Md.
- MACCUBBIN, Howard A.** (*M* 1934) Buyer, Htg. Equip., Montgomery Ward & Co., and •4914 N. Mason Ave., Chicago, Ill.
- MACDONALD, Donald B.** (*M* 1930) Engr., Sordoni Construction Co., 45 Owens St., Forty Fort, and •101 E. Walnut St., Kingston, Pa.
- MACDONALD, Douglas J.** (*M* 1935) Vice-Pres., Htg. Div., •Standard Sanitary Dominion Radiator Co., Ltd., Royce and Lansdowne Aves., and 96 Hudson Dr., Toronto, Ont., Canada.
- MacEACHIN, Graham C.** (*M* 1938) Major, 852nd Engineer Aviation Battalion, Geiger Field, Wash.
- MACFARLAN, Norris S.** (*M* 1942) Htg. Engr., The Philadelphia Gas Works Co., 1401 Arch St., Philadelphia, and •320 W. Wharton Rd., Glenside, Pa.
- MacGREGOR, Cecil M.** (*A* 1939) Capt., F. A., U. S. Army, Field Artillery School, Fort Sill, and •Box 1193, Lawton, Okla.
- MACHEN, James T.** (*A* 1938; *J* 1934) Asst. Vice-Pres., •The Ric-wil Co., 1562 Union Commerce Bldg., and Sterling Hotel, Cleveland, Ohio.
- MACHIN, Donald W.** (*A* 1943; *J* 1935) Fuel Service Engr., Pittsburgh & Midway Coal Mining Co., 610 Dwight Bldg., Kansas City, Mo., and •2112 Vermont St., Lawrence, Kan.
- MACK, Emil H.** (*A* 1938) Asst. Sales Mgr., The Vilter Manufacturing Co., 2217 S. First St., and •2225 N. Booth St., Milwaukee, Wis.
- MACK, Ludwig** (*M* 1935) Dist. Mgr., Cooling and Air Cond. Div., B. F. Sturtevant Co., Cresmont and Haddon Aves., Camden, N. J., and •412 W. Horter St., Philadelphia, Pa.
- MacLACHLAN, Victor D.** (*A* 1939; *J* 1938) Flight Lt., R. A. F. V. R., •Honeywell-Brown, Ltd., Wadsworth Rd., Perivale, Greenford, Middlesex, and R. A. F. Station, Digby, Lincoln, England.
- MacLEAN, H. A.** (*M* 1939) Mgr., •The MacLean Plumbing Service, P. O. Box 400, and 89 Tremoy Rd., Noranda, Que., Canada.
- MacMILLAN, Alexander R.** (*M* 1936) Mgr., Delco Appliance Div., •General Motors Sales Corp., 2-160 General Motors Bldg., and 2455 Longfellow Ave., Detroit, Mich.
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- MACROW, Lawrence** (*A* 1941; *J* 1936) Dist. Chief Engr., •Carrier Corp., 12 South 12th St., Philadelphia, and 225 Buttonwood Way, Glenside Heights, Pa.
- MacWATT, Donald A.** (*M* 1938) Sales Engr., Powers Regulator Co., 231 East 46th St., New York, and •Plandome, L. I., N. Y.
- MADDEN, Alfred B.** (*M* 1942) Mgr., Htg. Div., •Crane, Ltd., Beaver Hall Hill, and 5367 Earncliffe Ave., Montreal, Que., Canada.
- MADDUX, O. Lloyd** (*M* 1935; *A* 1933) Owner, O. Lloyd Maddux, 53 Park Pl., New York, N. Y., and •17 Tallmadge Ave., Chatham, N. J.
- MADELY, Frederick J.** (*A* 1936) Chief Estimator, Eastern Steel Products, Ltd., 1335 Delormier Ave., and •6370 Louis-Hemon St., Montreal, Que., Canada.
- MADISON, Richard D.** (*M* 1926) Research Engr., •Buffalo Forge Co., 490 Broadway, Buffalo, and 218 Brantwood Rd., Snyder, N. Y.
- MAEHLING, Leon S.** (*M* 1932) Supt. of Service, Equitable Gas Co., 6304 Penn. Ave., and •778 Country Club Dr., Pittsburgh, Pa.
- MacIRL, Willis J.** (*M* 1934; *A* 1931; *J* 1927) Chief Engr., •P. H. MacGill Foundry & Furnace Works, 401-13 E. Oakland Ave., and 1119 E. Monroe St., Bloomington, Ill.
- MAGNUSSON, Nicholas** (*A* 1938) Estimator-Designer-Sales, Montgomery Ward & Co., 150-15 Jamaica Ave., and •138-05 Linden Blvd., Jamaica, L. I., N. Y.
- MAHON, Miss B. B.** (*M* 1935) Principal of Air Cond., •International Correspondence Schools, Wyoming Ave. and Ash St., and 433 Fig St., Scranton, Pa.
- MAHON, Frank B.** (*M* 1937) Industrial Sales Promotion, •Duquesne Light Co., 435 Sixth Ave., and 290 LeMoyné Ave., Pittsburgh, Pa.
- MAHONEY, David J.** (*M* 1930; *A* 1926) Branch Mgr., •Johnson Service Co., 503 Franklin St., and 140 Linwood Ave., Buffalo, N. Y.
- MAIER, George M.** (*M* 1921) •American Radiator & Standard Sanitary Corp., Bessemer Bldg., Room 1226, Pittsburgh, and 135 Longue Vue Dr., Mt. Lebanon, Pa.
- MAIER, Herman F.** (*M* 1926) Chief Engr.-Secy., •New York Blower Co., 3155 Shields Ave., and 7124 S. Morgan St., Chicago, Ill.
- MAKIN, Henry T., Jr.** (*M* 1939) Engr. and Archts. Repr., American Radiator & Standard Sanitary Corp., 2212 Walnut St., and •301 Wadsworth Ave., Philadelphia, Pa.
- MALIN, Benjamin S.** (*M* 1940; *J* 1939) Capt., Ordnance Dept., U. S. Army, Asst. to Works Mgr., Bldg. 104, Springfield Armory, and •107 High St., Springfield, Mass.
- MALLIS, William** (*M* 1914) Owner, •330 Lyon Bldg., and 723 Federal Ave., Seattle, Wash.
- MALLY, Chester F.** (*M* 1940; *A* 1938) Gen. Mgr., Chief Engr., Air Heating Co., 20420 Woodward Ave., Detroit, and •292 W. Woodland Ave., Ferndale, Mich.
- MALONE, Dayle G.** (*M* 1929; *A* 1925) Branch Mgr., •Petroleum Heat & Power Co., 3301 S. California Ave., and 7337 Merrill Ave., Chicago, Ill.
- MALONE, James S.** (*A* 1936) Dist. Repr., •Hoffman Specialty Co., 4 N. Eighth St., and 7124 Waterman Ave., St. Louis, Mo.
- MALVIN, Ray C.** (*M* 1929) Pres., •Malvin & May, Inc., 2015 S. Michigan Ave., and 8220 Dante Ave., Chicago, Ill.
- MANDELL, Thomas P.** (*A* 1937) Sales, Carrier Corp., 1200 Statler Office Bldg., and •192 Commonwealth Ave., Boston, Mass.
- MANK, Merrill** (*A* 1939) Owner, •Merrill Mank Co., 14 Bonnefoy Pl., and 15 North Ave., New Rochelle, N. Y.
- MANN, Walter N.** (*M* 1939) Gen. Mgr., Brockhouse Heater Co., Ltd., Victoria Works, West Bromwich, Staffs., and •"Moneymore," Canwell, Sutton Coldfield, Warwickshire, England.
- MANNEN, D. Edward, Jr.** (*J* 1939) Vice-Pres., The Mannen & Roth Co., 9108 Woodland Ave., Cleveland, and •4157 Silsby Rd., University Heights, Ohio.
- MANNING, C. E.** (*J* 1937) Product Engr., Packard Electric Div., General Motors Corp., and •195 Linden Ave. S.E., Warren, Ohio.
- MANNY, J. Harvey** (*A* 1936) Pres., •Robinson Furnace Co., 213 W. Hubbard St., and 242 N. Parkside Ave., Chicago, Ill.
- MARCONETT, Vernon G.** (*A* 1936) Supt., The Farquhar Furnace Co., and •216 Fulton St., Wilmington, Ohio.
- MARIN, Axel*** (*M* 1935) Assoc. Prof. Mech. Engrg., •University of Michigan, 241 W. Engineering Bldg., and P. O. Box 175, Ann Arbor, Mich.
- MARINO, Frank A.** (*A* 1941) Tech. Sgt., U. S. Army, and •3348-28th St., Long Island City, N. Y.
- MARKERT, John W.** (*A* 1940) Naval Archt., Htg. and Vtg., U. S. Maritime Commission, Room 4525, Dept. of Commerce Bldg., Washington, D. C., and •8506 Garfield St., Bethesda, Md.
- MARKLAND, Charles E.** (*M* 1939) Supervising Engr., •University of Illinois, Urbana, and 807 W. Clark St., Champaign, Ill.
- MARKS, Alexander A.** (*A* 1930) Chief Engr., Richmond Radiator Co., 818 Fayette Title & Trust Bldg., Uniontown, Pa.
- MARKSON, Wesley H.** (*J* 1942) Junior Engr., McQuay Inc., 1600 Broadway N.E., and •428 Russell Ave. N., Minneapolis, Minn.
- MARKUSH, Emery U.** (*M* 1931) Secy., •Eastern Mechanical Corp., 225 East 21st St., New York, and 84-30-85th Ave., Woodhaven, L. I., N. Y.

ROLL OF MEMBERSHIP

- MARRINER, John M. S.** (M 1934) Vice-Pres., • Taylor Engineering & Construction Co., Ltd., 80 Richmond St. W., and 111½ Balsam Ave., Toronto, Ont., Canada.
- MARSHALL, Peter J.** (M 1930; J 1927) Engr., The Austin Co., 221 N. LaSalle St., Chicago, and •2009 Greenwood Ave., Wilmette, Ill.
- MARSHALL, Albert W.** (M 1937) Inspector and Engr., Hartford Steam Boiler Inspection & Insurance Co., 1806 Arrott Bldg., Pittsburgh, and •1120 Highview Rd., Dravosburg, Pa.
- MARSHALL, James** (A 1943; J 1939) Engr., The Bahnson Co., 1001 S. Marshall St., and •Apt. A 3-108 Twin Castles, Winston-Salem, N. C.
- MARSHALL, Orville D.** (M 1942; A 1931) Mfrs. Agent, •311 Anderson Bldg., and 1440 Fisk Rd., S.E., Grand Rapids, Mich.
- MARSHALL, Stanley C.** (M 1939) Chief Engr., Mayflower-Lewis Corp., Duluth and East Seventh St., St. Paul, and •2735 Toledo, Minneapolis, Minn.
- MARSHALL, Thomas A.** (A 1943; J 1937) Lt., Technical Division V, Engineer Board, Ft. Belvoir, Va., and •195 Eureka St., San Francisco, Calif.
- MARSHALL, William D.** (M 1935) Branch Mgr., Noland Co., Inc., 1823 N. Arlington Ridge Rd., and •3232 Woodrow St. N., Arlington, Va.
- MARSTON, Anson D.*** (A 1937) Major, G. S. C., Asst. to A. C. of S. (G-3) Headquarters V, Army Corps, Camp Beauregard, La.
- MART, Leon T.** (M 1941) Pres., •The Marley Co., 3001 Fairfax Rd., Kansas City, Kan., and 6840 Tomahawk Rd., Kansas City, Mo.
- MARTENS, E. D.** (M 1937) Gen. Mgr., •F. Brutschy Co., Inc., Pentagon Bldg., Arlington, Va., and 89 Eldridge Ave., Hempstead, L. I., N. Y.
- MARTIN, Albert B.** (M 1917) Branch Mgr., •Kewanee Boiler Co., 549 W. Washington Blvd., Chicago, and 997 Vine St., Winnetka, Ill.
- MARTIN, George D.** (M 1941) Branch Mgr., Grinnell Company of Pacific, 601 Brannan St., and •1543 Willard St., San Francisco, Calif.
- MARTIN, George W.*** (Life Member; M 1911) Supervising Engr., •U. S. Realty & Improvement Co., 111 Broadway, New York, N. Y., and 340 Prospect St., Ridgewood, N. J.
- MARTIN, John O.** (A 1939) Partner, •J. O. & C. U. Martin, 637 Minna St., San Francisco, and 328 Jerome Ave., Piedmont, Calif.
- MARTIN, Raymond** (A 1937) Sales Engr., •Vapor Car Heating Company of Canada, Ltd., 65 Dalhousie St., Montreal, and 9 Morris Ave., Ste. Therese, Que., Canada.
- MARTOCCELLO, Joseph A.** (M 1934) Pres., Jos. A. Martocello & Co., 229 North 13th St., Philadelphia, Pa.
- MARTY, Edgar O.** (M 1916) Mining, Elec. and Mech. Engr., Parsons, Klapp, Brinckerhoff & Douglas, 142 Maiden Lane, New York, and •84 Long Ridge Rd., Plandome, L. I., N. Y.
- MARTYN, Henry J.** (A 1937) Pres., •Martyn Bros., Inc., 911 Camp St., and 5306 Ridgedale St., Dallas, Texas.
- MARVIN, John H.** (A 1942) Mgr., John H. Marvin Co., 1016 First Ave. S., Seattle, Wash.
- MARZOLF, Frank X.** (A 1937) Sales Engr., Minneapolis-Honeywell Regulator Co., 415 Brainerd St., and •15790 St. Marys, Detroit, Mich.
- MASON, Ray B.** (M 1925) Sales Engr., •Kewanee Boiler Corp., 2014 Wyandotte St., and 121 East 70th Terrace, Kansas City, Mo.
- MAST, Clyde M.** (A 1940) Heating & Air Conditioning Supply, Inc., 263 Sierra St., and •536 Nixon St., Reno, Nev.
- MATCHETT, James C.** (M 1923) Vice-Pres. and Gen. Mgr., •Illinois Engineering Co., Racine Ave. and 21st St., and 9936 S. Winchester Ave., Chicago, Ill.
- MATHEKA, Charles R.** (S 1939) •U. S. S. Tattnall c/o Postmaster General, New York, N. Y., and 1506 Summit Ave., Union City, N. J.
- MATHER, Harry H.** (A 1929) Treas., Mather Paper Co., 611 S. Front St., Philadelphia, and •373 Lakeview Ave., Drexel Hill, Pa.
- MATHEWSON, M. E.** (M 1937) Secy., •A. M. Kinney, Inc., 1301 Enquirer Bldg., and 3569 Erie Ave., Cincinnati, Ohio.
- MATHIS, Eugene*** (M 1922) Vice-Pres. and Treas., •The New York Blower Co., 32nd St. and Shields Ave., Armour P. O. Station, and 9151 S. Hoyne Ave., Chicago, Ill.
- MATHIS, Henry** (M 1921) The New York Blower Co., 32nd St. and Shields Ave., Armour P. O. Station and •11246 Longwood Dr., Chicago, Ill.
- MATHIS, John** (A 1938) Engr., •Standard Furnace & Supply Co., 413 S. Tenth St., and 3663 Davenport St., Omaha, Nebr.
- MATHIS, Julien W.** (A 1921) •New York Blower Co., 3145-55 Shields Ave., and 7929 Bishop St., Chicago, Ill.
- MATHISON, Russell St. Clair** (A 1938) Asst. Mgr., Weathermakers (Canada), Ltd., 593 Adelaide St. W., and •44 Strathgowan Ave., Toronto, Ont., Canada.
- MATOUSEK, A. G.** (M 1937) Mgr., Gamble Store, Schuyler, Nebr.
- MATTHEWS, John E.** (M 1934) Sales Engr., B. F. Sturtevant Co., Crestmont and Haddon Ave., Camden, and •300 Chestnut St., Haddonfield, N. J.
- MATTHIES, Leo A.** (S 1941) Ensign, U. S. N. R., •B. O. 2, Naval Air Station, Seattle, Wash., and 4433-18th Ave. S., Minneapolis, Minn.
- MATTINGLY, Maurice F.** (A 1939) Sales Engr., •Johnson Service Co., 1355 Washington Blvd., and 8028 Ingleside Ave., Chicago, Ill.
- MATZ, George N.** (M 1938) Mech. Engr., A. Ernest D'Ambly, 2101 Architects Bldg., Philadelphia, and •649 Ferne Ave., Drexel Hill, Pa.
- MATZEN, Harry B.** (M 1919) Consulting Mech. Engr., 185 Madison Ave., New York, and 16 Addison Pl., Rockville, Center, L. I., N. Y., and •3716 Belmont Rd., Mariemont, Ohio.
- MAURER, Lester** (M 1941) Air Cond. Engr. Navy Dept., and •1835-19th St. N.W., Washington, D. C.
- MAVES, G. D.** (A 1939) Sales Engr., •Minneapolis-Honeywell Regulator Co., 1031 Santa Fe Dr., and •1550 Glencoe St., Denver, Colo.
- MAWBY, Pensyl** (M 1934) Dist. Sales Mgr., Lehigh Navigation Coal Co., 123 S. Broad St., Philadelphia, and •15 E. Ridley Ave., Ridley Park, Pa.
- MAXWELL, George W.** (M 1935; S 1932) Engr., Kenely & Maxwell, Main St., and •Lower County Rd., Harwich Port, Mass.
- MAXWELL, R. Sherlaw** (M 1937) Gen. Mgr., •Bennett & Wright, Ltd., 72 Queen St. E., and 107 Cheltenham Ave., Toronto, Ont., Canada.
- MAY, Arthur O.** (A 1938; J 1928) Secy., •Stanard Power Equipment Co., 53 W. Jackson Blvd., Room 925, and 5736 N. Bernard St., Chicago, Ill.
- MAY, C. W.** (M 1933) Consulting Engr., •817 Smith Tower, and 6056 Fourth N.E., Seattle, Wash.
- MAY, Edward M.** (M 1931) Branch Mgr. and Combustion Engr., Steel Products Engineering Co., 1601 S. Michigan Ave., Chicago, and •848 N. Ridgeland Ave., Oak Park, Ill.
- MAY, George Elmer*** (M 1933) Utilization Engr., New Orleans Public Service, Inc., 317 Baronne St., New Orleans, La.
- MAY, James W.** (M 1938; J 1935) Assoc. Prof. of Htg. and Vtg., •College of Engrg., University of Kentucky, and 1046 Fontaine Rd., Lexington, Ky.
- MAY, Maxwell F.** (M 1929) Vice-Pres., •Young Radiator Co., Racine, Wis., and Palos Park, Ill.
- MAYNARD, J. Earle** (M 1931) Dir. of Engrg., •Rybolt Heater Co., Ashland, and 324 Fifth St., Elyria, Ohio.
- MAYNE, Walter L.** (M 1938) Vice-Pres., Sales Mgr., •Marsh Valve Co., Brigham Rd., at Fourth St., and 718 Washington Ave., Dunkirk, N. Y.
- McBRIDE, J. Nevins** (A 1941) Vice-Pres., •Frank A. McBride Co., 158-180 Ward St., and 228 Derrom Ave., Paterson, N. J.

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- McCAFFRAY, Charles E.** (M 1938) Western Electric Co., and •5700 Cross Country Blvd., Baltimore, Md.
- McCAIN, H. King** (M 1939; A 1938; J 1937) 1st Lt., Q. M. C., •Staff and Faculty, The Quartermaster School, Camp Lee, and Route No. 1 (Cedar Level), Hopewell, Va.
- McCALLUM, Chester E.** (M 1941) Mgr., Production Service Div., War Production Board, 426 Law Bldg., Charlotte, N. C.
- McCANN, Frank D.** (A 1939) Supvr. Air Cond. and Comm. Refrig., •Westinghouse Electric & Manufacturing Co., 40 Wall St., New York, and 378 Scarsdale Rd., Crestwood, Yonkers, N. Y.
- McCAUL, Lynn K.** (M 1942) Sales Engr., The Coon-DeVisser Co., Detroit, and •622 W. Marshall, Ferndale, Mich.
- McCAULEY, James H.** (M 1921) Pres. •J. H. McCauley & Son, 5620 West 65th St., Chicago, and 707 William St., River Forest, Ill.
- McCLANAHAN, L. C.** (M 1930) Dist. Mgr., •Aerofin Corp., 603 Great National Life Bldg., and 811 S. Tyler, Dallas, Texas.
- McCLELLAN, James E.** (M 1922) Office Mgr., •American Blower Corp., 228 N. LaSalle St., Chicago, and 738 Marion Ave., Highland Park, Ill.
- McCLINTOCK, William** (M 1935) Consulting Engr., •647 East 232nd St., New York, N. Y.
- McCLOSKEY, John H.** (A 1940) Owner, J. H. McCloskey, 109 North St., and •304 Elkton Blvd., Elkton, Md.
- McCLUNG, Tom H.** (A 1942; J 1939) 1403 D St., Lawton, Okla.
- McCONACHIE, L. L.** (A 1928) Owner •L.L. McConachie Co., 1003 Maryland Ave., Detroit, and 1415 Harvard Rd., Grosse Pointe Park, Mich.
- McCONNER, Charles R.** (A 1925; J 1922) Gen. Sales Mgr., •Clarage Fan Co., and 1904 Waite Ave., Kalamazoo, Mich.
- McCORMACK, Denis** (M 1933) Mgr. Commercial Instruments and Controls Dept., Julien P. Friez & Sons, Div. of Bendix Aviation Corp., 4 N. Central Ave., and •Ruxton Post Office, Baltimore, Md.
- McCORMICK, George W., Jr.** (A 1941) Chief, Liquid and Gas Handling Equipment Branch, W. P. B., and •1135-16th St. N.W., Washington, D. C.
- McCOY, C. E.** (M 1936) Partner •Turner-McCoy, 315 W. Second St., and 5117 Sherwood Rd., Little Rock, Ark.
- McCOY, Thomas F.** (M 1924) Mgr., The Powers Regulator Co., 125 St. Botolph St., Boston, and •124 Babcock St., Brookline, Mass.
- McCREA, Joseph B.** (M 1937) Htg. and Vtg., 2919 Drexel Ave., Detroit, Mich.
- McCREA, Lester W.** (M 1920) Prop., •McCrea Sales Co., 15 East 21st St., and 564 W. University Pkwy., Baltimore, Md.
- McCULLEY, D. E.** (A 1917) Mfrs. Repr., Htg. Equip., •1101 Jackson St., and 5504 Corby St., No. 3, Omaha, Nebr.
- McCULLOUGH, Henry G.** (M 1936) Smaller War Plants Div., War Production Board, Washington, D. C., and •7042 Lincoln Dr., Mt. Airy, Philadelphia, Pa.
- McCULLOUGH, John L.** (M 1930) •Harry Dougherty & Son, Freeport, and 105 Roycroft Ave. (16), Pittsburgh, Pa.
- McCUSKER, James P.** (S 1940) Student, Catholic University of America, and •1445 Evans St. N.E., Washington, D. C.
- McDERMOTT, John P.** (A 1942; J 1939) •Engr. Corps, Fort Belvoir, Va., and 3534 S.E. Claybourne, Portland, Ore.
- McDONALD, Ivan** (A 1938) Brnch Mgr., •Minneapolis-Honeywell Regulator Co., 44 Princess St., and 132 Kingston Row, Winnipeg, Man., Canada.
- McDONALD, Thomas** (A 1931) Vice-Pres., •Minneapolis-Honeywell Regulator Co., 1135 N. Cicero Ave., Chicago, and 7855 Greenfield Ave., River Forest, Ill.
- McDONNELL, Everett N.** (M 1923) (Council, 1940-42) Pres., •McDonnell & Miller, 400 N. Michigan Ave., and 219 Lake Shore Dr., Chicago, Ill.
- McDONNELL, John E.** (A 1936) Sales Engr., •McDonnell & Miller, 400 N. Michigan Ave., Chicago, and 2299 Lakeside Pl., Highland Park, Ill.
- McDOWELL, Harry L.** (J 1939) Ensign, U.S.N.R. and •1128 Belt Line Blvd., Columbia, S. C.
- McELGIN, John W.*** (A 1937; J 1931) Engr., J. J. Nesbitt, Inc., Holmesburg, Philadelphia, and •260 Clevedon Ave., Glenside, Pa.
- McENTEE, Francis M.** (M 1940) Asst. Supervising Air Cond. Engr., •Office of the Architect, U. S. Capitol, and 718 Somerset Pl., Washington, D. C.
- McFARLAN, A. I.** (M 1942) Vice-Pres., Kerby Saunders, Inc., 330 West 42nd St., New York, N. Y., and •691 Dorian Rd., Westfield, N. J.
- McGEORGE, Richard H.** (M 1927) Mgr., Htg., Air Cond. Dept., McCord Radiator & Manufacturing Co., 2587 E. Grand Blvd., and •14565 Glastonbury Rd., Detroit, Mich.
- McGINNIS, Frank L.** (M 1940) Mech. Supt., Virginia Engineering Co., Elizabeth City, N. C., and •332 N. Henry St., Williamsburg, Va.
- McGONAGLE, Arthur** (M 1932) Consulting Engr., 6815 Prospect Ave., Ben Avon, Pa.
- McGOWAN, T. Edward** (M 1942) Chief Mech. Supt., Synthetic Rubber Plant, Stone & Webster Engineering Corp., Gardena, and •1545 Bradbury Rd., San Marino, Calif.
- McGOWN, Frederick H., Jr.** (J 1941; S 1939) P. O. Box 105, Cooperstown, N. Y.
- McGRAIL, Thomas E.** (M 1926) Local Repr., Canadian Sirocco Co., Ltd., 63 Sparks St., Ottawa, Ont., Canada.
- McILVAINE, John H.** (M 1929) Pres., Landwehr Heating Corp., Sixth and Cuyuga Sts., Philadelphia, and •801 Pembroke Rd., Bryn Mawr, Pa.
- McINDOE, James F.** (M 1939; A 1931) Regional Supervisor, War Production Board, Room 270, 1355 Market St., San Francisco, and •1340 Bernal Ave., Burlingame, Calif.
- McINTIRE, James F.*** (M 1915; A 1914) (Presidential Member) (Pres., 1939; 1st Vice-Pres., 1938; 2nd Vice-Pres., 1937; Council, 1926-28; 1932-40) 1st Vice-Pres., •U. S. Radiator Corp., Pres., Pacific Steel Boiler Corp., 1500 United Artists Bldg., and 3261 Sherbourne Rd., Detroit, Mich.
- McINTOSH, Fabian C.** (M 1921; J 1917) (Council, 1929-31; 1933-35; 1942) Branch Mgr., •Johnson Service Co., 1238 Brighton Rd., and 3650 Perryville Ave., Pittsburgh, Pa.
- McKAY, Albert W.** (M 1942) Capt., Ordnance Dept., Office—Chief of Ordnance, and •1629 Columbia Rd. N.W., Washington, D. C.
- McKEEMAN, Clyde A.*** (M 1936) Assoc. Prof. of Mech. Engrg., •Case School of Applied Science, 10900 Euclid Ave., Cleveland, and 4035 Bluestone Rd., Cleveland Heights, Ohio.
- McKENZIE, Murdock Charles, Jr.** (M 1938) Htg. Engr., Southern California Gas Co., 810 S. Flower St., and •3806 Boyce Ave., Los Angeles, Calif.
- McKERNAN, Gordon S.** (A 1942) Secy.-Treas., Reg. H. Steen, Ltd., 12 Humewood Dr., and •7 Grimthorpe Rd., Toronto, Ont., Canada.
- McKINNEY, Carl A.** (A 1939; J 1937) Air Cond. Engr., •United Gas Corp., United Gas Bldg., and 2136 Addison Rd., Houston, Texas.
- McKINNEY, William J.** (M 1938; A 1934) Dist. Mgr., •American Blower Corp., Room 714, 101 Marietta St. Bldg., and 3363 Mathieson Dr. N.W., Atlanta, Ga.
- McKITTRICK, Walter D.** (M 1936) Mech. Engr., •M. P. H. Co., N. O. B., Bermuda, and 3632 Detroit Ave., Toledo, Ohio.
- McKITTRICK, Percy A.** (A 1934) Treas., Gen. Mgr., •Parks-Cramer Co., P. O. Box 444, and 219 Blossom St., Fitchburg, Mass.

ROLL OF MEMBERSHIP

- McLAREN, T. H.** (A 1938) Gen. Sales Mgr., •The James Morrison Brass Manufacturing Co., Ltd., 276 King St. W., and 2084 Girard St. E., Toronto, Ont., Canada.
- McLARNY, Harry W.** (M 1933) Industrial Engr., •Union Electric Company of Missouri, 315 North 12th Blvd., St. Louis, and 807 Hawbrook Rd., Glendale, Mo.
- McLEAN, Dermid** (M 1917) Mech. Engr., •Snyder & McLean, 2214 Penobscot Bldg., and 12651 Birwood Ave., Detroit, Mich.
- McLEISH, William S.** (A 1932; J 1928) Chief Engr., •The Ric-wil Co., and Overlook and Hillcrest, Barberton, Ohio.
- McLENEGAN, D. W.*** (M 1933) Engr. in charge, Air Cond. and Commercial Refrig. Dept., •General Electric Co., 5 Lawrence St., Bloomfield, and 73 Arlington Ave., Caldwell, N. J.
- McLOUTH, Bruce F.** (M 1936; J 1934) Mech. Engr., •Office Chief of Engrs., U. S. Army, R. & U. Branch, War Bldg., Washington, D. C., and 135 Gunston St., East Lansing, Mich.
- McMAHON, Thomas W.** (M 1928) Dist. Mgr., •American Blower Corp., 1711 Railway Exchange Bldg., and 6173 Waterman Blvd., St. Louis, Mo.
- McMULLEN, Ernest W.** (M 1942) Partner, Ganteaume & McMullen, 90 Chauncy St., Boston, and •103 Bynner St., Jamaica Plain, Mass.
- McMULLEN, E. W.** (M 1938) Dir. of Research, •The Eagle-Picher Lead Co., and Olivia Apts., Joplin, Mo.
- McNAMARA, William** (A 1930) Mgr., •The Trane Co., 850 Cromwell Ave., and 1355 Como Ave. W., St. Paul, Minn.
- McNAMEE, Earl W.** (M 1940) Air Cond. Engr., •B. & J. Jacobs Co., 1729 John St., and 2627 Ocosta Ave., Cincinnati, Ohio.
- McNEVIN, Joseph E.** (M 1937) Owner, •Colorado Heating Co., 950 Cherokee St., and 1221 Sherman St., Apt. 37, Denver, Colo.
- McPHERSON, William A.** (M 1929) Chief, Htg., Vtg. Div., Dept. of School Bldg., 26 Norman St., Boston, and •86 Dwinnell St., West Roxbury, Mass.
- McQUAID, Dan J.** (M 1934) Owner, •Dan J. McQuaid Engineering Service, 1742-46 Arapahoe St., and 1565 Milwaukee St., Denver, Colo.
- McRAE, M. W.** (M 1939) Research Engr., •Crane Co., 836 S. Michigan Ave., Chicago, and 816 Fairview Ave., Park Ridge, Ill.
- McWILLIAMS, Joseph W.** (A 1942) Mech. Engr., Eastman Kodak Co., Camera Works, 333 State St., and •250 Chili Gates T. L. Rd., R. F. D. No. 5, Rochester, N. Y.
- MEAD, E. A.** (M 1926) Sales Mgr., Nash Engineering Co., South Norwalk, Conn.
- MEAD, George E.** (A 1941) Owner, •George E. Mead Co., Seattle Construction Center, Frye Hotel Bldg., and 4729-38th Ave. N.E., Seattle, Wash.
- MEAD, H. K.** (A 1939) Htg. and Vtg. Equipment, •1100 Guardian Bldg., Portland, and Jennings Lodge, Ore.
- MEAGHER, Arthur T.** (M 1938) Dir. and Sales Mgr., Pibg. and Htg. Dept., Wm. Stairs, Son & Morrow, Ltd., 174-190 Lower Water St., and •83 Seymour St., Halifax, Nova Scotia, Canada.
- MEHNE, Carl A.** (M 1929) Htg., Vtg. Expert, 35 Livingston St., Valhalla, N. Y.
- MEILLER, Daniel V.** (A 1941) Supvr., Gas Utilization and Testing, •Public Service Company of Northern Illinois, 1001 S. Taylor Ave., Oak Park, and 1101 S. Fifth Ave., Maywood, Ill.
- MEINHOLTZ, Herbert W.** (M 1936) Sales Engr., York Ice Machinery Corp., 215 Investment Bldg., 12th and K. N.W., Washington, D. C.
- MEINKE, Howard G.** (M 1933) Div. Engr., •Consolidated Edison Company of New York, Inc., 4 Irving Pl., Room 1500, New York, and 41 Harte St., Baldwin, L. I., N. Y.
- MELLON, James T. J.** (M 1911) (Council, 1915) Pres., •Mellon Co., 4419 Ludlow St., and 431 North 63rd St., Philadelphia, Pa.
- MELNICK, Nicholas A.** (M 1941) Engr., G. M. Simonson, Consulting Engr., 625 Market St., and •279 Fifth Ave., San Francisco, Calif.
- MELONEY, Edward J.** (M 1930) Vice-Pres., Secy., •Bowers Bros. Co., 2015 Sansom St., Philadelphia, and 100 E. Stewart Ave., Lansdowne, Pa.
- MELTON, Howard E.** (A 1942) Mgr., •Howard E. Melton, Inc., 1017 N. Harvey, and 1709 Pennington, Oklahoma City, Okla.
- MELTON, Rupert D.** (J 1942) Asst. Engr., Page & Co., 219 S. Mint St., and •117 W. Tenth St., Charlotte, N. C.
- MENDEN, Peter J.** (M 1935) Heating and Piping Designer, The Austin Co., 220 W. Main St., Midland, and •1901 Third St., Bay City, Mich.
- MENSING, Frederick D.** (M 1920) (Treas., 1931-32), (Council, 1931-32), Consulting Engr., Mensing & Co., 2845 Frankford Ave., Philadelphia, Pa.
- MERENS, Seymour H.** (A 1939) Vice-Pres., Max Miller & Co., 823 N. California Ave., and •4955 N. Whipple St., Chicago, Ill.
- MERGARDT, Albert P.** (A 1940) Owner, •American Heating Co., 55 K St. S.E., Washington, D. C., and 3905 N. Fifth St., Arlington, Va.
- MERRILL, Carle J.** (M 1919) Treas., •C. J. Merrill, Inc., 54 St. John St., and 31 Craigie St., Portland, Me.
- MERRILL, Frank A.** (M 1934) Consulting Engr., •Office of Hollis French, 210 South St., Boston, and 19 Auburndale Rd., Marblehead, Mass.
- MERZ, Robert A.** (S 1940) Student, Michigan State College, and •810 W. Grand River Ave., East Lansing, Mich.
- MERTZ, Walter A.** (M 1919) Secy., •The Kehm Bros. Co., 61 E. Grand Ave., and 3753 N. Keeler Ave., Chicago, Ill.
- MERWIN, Gile E.** (M 1924; J 1923) Dist. Mgr., The Trane Co., 5012 Parker St., Omaha, Nebr.
- METZGER, A. F.** (M 1940) Supvr. of Steam Utilization Div., •Allegheny County Steam Heating Co., 435 Sixth Ave., and 3421 Horne St., Pittsburgh, Pa.
- METZGER, H. J.** (A 1937) Pres., Wheeler-Blaney Co., 137 E. Water St., Kalamazoo, Mich.
- MEYER, Frank L.*** (M 1932; J 1928) Pres., •The Meyer Furnace Co., and 9 Cole Court, Peoria, Ill.
- MEYER, Henry C., Jr.*** (Life Member; M 1898) (Council, 1915-16) Pres., •Meyer, Strong & Jones, Inc., 101 Park Ave., New York, N. Y., and 25 Highland Ave., Montclair, N. J.
- MEYER, Karl A.** (M 1938) Senior Draftsman, Whiting Corp., Harvey, and •12251 Western Ave., Blue Island, Ill.
- MEYERS, Carl F.** (A 1942) Engr., Coblentz Equipment Co., 1119 Peach St., and •142 East 35th St., Erie, Pa.
- MICHIE, D. Fraser** (M 1938; A 1930) Htg. Engr., •Crane, Ltd., 93 Lombard St., and 176 Green Ave., Winnipeg, Man., Canada.
- MILNER, Eugene D.** (M 1936) Secy., Industrial & Commercial Gas Section, American Gas Assn., 420 Lexington Ave., Suite 550, New York, N. Y.
- MILES, James C.** (M 1914) Research Engr., The Geometric Stamping Co., 1111 East 200th St., and •2007 East 115th St., Cleveland, Ohio.
- MILLARD, Junius W.** (M 1929) Lt., U. S. Navy, Atlantic Fleet, and •1025 Laird St., Key West, Fla.
- MILLER, Archibald T.** (M 1938) Mgr. Insulation Sales, The Barrett Div., Allied Chemical & Dye Corp., 40 Rector St., New York, N. Y., and •125 Godwin Ave., Ridgewood, N. J.
- MILLER, Bruce R.** (M 1935; A 1930) Mech. Engr., R. K. Werner, Consulting Engr., 316 W. T. Waggoner Bldg., Fort Worth, Texas.
- MILLER, Charles A.** (A 1917) Sales, The H. B. Smith Co., Inc., 331 Madison Ave., New York, N. Y.
- MILLER, Charles W.** (M 1919; J 1908) Pres., •The Rado Co., 759 N. Milwaukee St., Room 405, Milwaukee, and R-1, Box 42, Menomonee Falls, Wis.

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- MILLER, Edgar R.** (A 1935) Chief Engr., • Winnipeg Cold Storage Co., Ltd., Salter and Jarvis Ave., and P. O. Box 1384, Winnipeg, Man., Canada.
- MILLER, Floyd A.** (M 1911) Inspection Engr., Federal Works Agency, U. S. Government, 377 U. S. Court House, and •944 Montrose Ave., Chicago, Ill.
- MILLER, George F.** (M 1936) Sales Engr., •George F. Miller, 1614 K St. N.W., Washington, D. C., and 5608 Grove St., Chevy Chase, Md.
- MILLER, Jacob** (M 1936) Pres., •Hy-Grade Construction Co., Inc., 342 West 14th St., New York, and 20 East 58th St., Brooklyn, N. Y.
- MILLER, John W.** (M 1941) Research Engr., Motor Wheel Corp., and •R. 2, Box 602, Lansing, Mich.
- MILLER, Leo B.** (M 1926) Sales Exec., •Perfex Corp., 500 W. Oklahoma Ave., and 3481 N. Hackett Ave., Milwaukee, Wis.
- MILLER, Lorin G.*** (M 1933) (Council, 1942) Head, Mech. Engrg. Dept., •Michigan State College, R. E. Olds Hall of Engrg., and 232 University Dr., East Lansing, Mich.
- MILLER, Mahlon S.** (A 1942) Sales Engr., •Iowa Public Service Co., and 917 W. Main St., Cherokee, Iowa.
- MILLER, Robert A.*** (M 1931) Tech. Sales Engr., •Pittsburgh Plate Glass Co., 2200 Grant Bldg., Pittsburgh, and 1211 Carlisle St., Tarentum, Pa.
- MILLER, Robert T.** (A 1927) Chief Engr., Sales Dept., •Masonite Corp., 111 W. Washington St., Chicago, and Evans Rd., Flossmoor, Ill.
- MILLER, William T.** (M 1938) Prof. Htg., Vtg., •Purdue University, and 525 Hayes St., West Lafayette, Ind.
- MILLHAM, Franklyn B.** (M 1938) Sr. Industrial Specialist, General Industrial Equipment Div., War Production Board, 1641 Temporary S Bldg., and •2505 N St. S.E., Washington, D. C.
- MILLIKEN, J. H.*** (M 1923) Repr., •American Air Filter Co., Inc., 228 N. LaSalle St., Chicago, and 1021 Ridge Court, Evanston, Ill.
- MILLIS, Linn W.** (Life Member; M 1918) Secy., Security Manufacturing Co., 1630 Oakland Ave., and •3534 Wabash Ave., Kansas City, Mo.
- MILLS, D. M.** (A 1940) Mgr., Houston Div., •F. J. Evans Engineering Co., 3223 Milan St., and 711 W. Alabama, Houston, Texas.
- MILLS, Hartzell C.** (A 1935) Sales Engr., Minneapolis Gas Light Co., Eighth and Marquette, and •4137 Tenth Ave. S., Minneapolis, Minn.
- MILNE, Arthur H.** (M 1938) Dir., Dept. of Bldgs., •Protestant Board of School Commissioners, City of Montreal, 3460 McTavish St., and 4786 Grosvenor Ave., Montreal, Que., Canada.
- MILWARD, Robert K.** (A 1920) Branch Mgr., •U. S. Radiator Corp., 127 Campbell Ave., and 2441 Calvert Ave., Detroit, Mich.
- MINER, H. Harvey** (A 1940) Partner, •Miner Supply Co., 129 W. Front St., Red Bank, and 71 Silverton Ave., Little Silver, N. J.
- MINKLER, William A.** (M 1940) Sales Mgr., Htg., Cooling and Air Cond. Div., Young Radiator Co., and •916 W. Lawn Ave., Racine, Wis.
- MIRABILE, J. James** (A 1938) Engr., •Thomas Shipley, Inc., 161 Roosevelt Ave., and 1525 Third Ave., York, Pa.
- MITCHELL, Alva E.** (M 1939) Chief, Plumbing Section, •War Production Board, U. S. Govt., 603 Steuart Bldg., Washington, D. C., and 6501 Sligo Pkwy., Hyattsville, Md.
- MITCHELL, A. J.** (M 1938; J 1930) Vice-Pres., Air Conditioning Co., 3215 McKinney Ave., Houston, Texas.
- MITCHELL, John G.** (A 1943; J 1937; S 1936) Sales Engr., •Fairbanks Morse & Co., 417 S. Fourth St., and 704 Delaware S.E., Minneapolis, Minn.
- MITTENDORFF, Edward M.** (M 1932) Engr., •Sarco Co., Inc., Merchandise Mart, Chicago, and 772 Grove St., Glencoe, Ill.
- MOESEL, F. Albert** (A 1939) Asst. Mgr., •W. A. Case & Son, Manufacturing Co., 31 Main St., Buffalo, and 382 Argonne Dr., Kenmore, N. Y.
- MOFFAT, Ormond George** (M 1940; A 1937) Mgr. Air Cond. Div., Canadian Westinghouse Co., and •141 George St., Hamilton, Ont., Canada.
- MOHN, H. Leroy** (M 1937) Chief Engr., Milton Manufacturing Co., and •705 Hepburn St., Milton, Pa.
- MOHRFELD, Herbert H.** (A 1943; J 1935) Engr. and Vice-Pres., •C. P. Mohrfeld, Inc., 24 Lees Ave., Collingswood, and 670 Station Ave., Haddonfield, N. J.
- MOLER, William H.** (M 1927) Dist. Mgr., •Governair Corp., 504 Great National Life Bldg., Dallas, and R. F. D. No. 1, Box 69B, Irving, Texas.
- MOLFINO, Philip** (M 1938) Mech. Engr., Leland & Haley, 58 Sutter St., and •125 Clayton St., San Francisco, Calif.
- MOLLANDER, Eric D.** (A 1940) Dir., Register & Grille Manufacturing Co., Inc., 70 Berry St., Brooklyn, and •1564 Unionport Rd., Parkchester, New York, N. Y.
- MOLLENBERG, Harold J.** (M 1936) Vice-Pres., •Mollenberg-Betz Machine Co., 22 Henry St., Buffalo, and 172 Westgate Rd., Kenmore, N. Y.
- MOLONEY, Roger R.** (M 1937) 26 Bonner Ave., Manly, Sydney, Australia.
- MONICK, Fred R.** (A 1936) Mgr., •American Radiator & Standard Sanitary Corp., 605 E. Eighth St., and 1114 S. Sixth Ave., Sioux Falls, S. D.
- MONTGOMERY, Edward G.** (A 1938) Special Repr., Steel Company of Canada, Ltd., 525 Dominion St., Montreal, and •20 Finchley Rd., Hampstead, Que., Canada.
- MONTGOMERY, John R.** (A 1937) Mgr., Standards & Research, Truscon Steel Co., Albert St., and 296 Granada Ave., Youngstown, Ohio.
- MOODY, Lawrence E.** (M 1919) Partner, •Moody & Hutchison, 1701 Architects Bldg., Philadelphia, Pa., and 224 Bellevue Ave., Haddonfield, N. J.
- MOON, L. Walter** (M 1915) (Council, 1933-36) Secy., Treas., St. Louis Industrial Truck Co., 7700 E. Railroad Ave., and •1137A Hornsby Ave., St. Louis, Mo.
- MOORE, Bryant W.** (A 1939) Mfrs. Agent, 36 S.W. Third St., and •7910 Southeast 30th Ave., Portland, Ore.
- MOORE, Frank C.** (A 1938) Canadian Mgr., Aerofin Corp., 67 Yonge St., and •44 Lola Rd., Toronto, Ont., Canada.
- MOORE, H. Carlton*** (M 1935) Engr., Design, Shreve, Lamb & Harmon, Fay, Spofford & Thorndyke, 11 Beacon St., Boston, and •145 Beaumont Ave., Newtonville, Mass.
- MOORE, H. Lee** (M 1919) (Council, 1927-28) Repr., •Buffalo Forge Co., 431 Fulton Bldg., and Flaccus Rd., Ben Avon, Pittsburgh, Pa.
- MOORE, Henry W.** (M 1935) 1st Lt., Cincinnati Ordnance District, U. S. War Dept., Big Four Bldg., and •1406 Myrtle Ave., Cincinnati, Ohio.
- MOORE, Herbert S.** (A 1923) Dist. Repr., Iron Fireman Manufacturing Company of Canada, Ltd., 602 King St., and •107 Clendenan Ave., Toronto, Ont., Canada.
- MOORE, MacDonald** (A 1940) Pres., Gen. Mgr., •The Moore Fuel Corp., 23 Rose St., and 14 Farview Ave., Danbury, Conn.
- MOORE, R. Edwin** (A 1928) Vice-Pres. in charge of Sales, •Bell & Gossett Co., 8200 N. Austin Ave., Morton Grove, and 425 Merrill Ave., Park Ridge, Ill.
- MOORE, Wesley Robert** (M 1937) Regional Mgr., •Minneapolis-Honeywell Regulator Co., 5005 Euclid Ave., Cleveland, and 14211 Ashwood Rd., Shaker Heights, Ohio.
- MORAWECK, Alvin H., Jr.** (J 1941) Lt., U. S. Army, and •36 Woodland Rd., Maplewood, N. J.

ROLL OF MEMBERSHIP

- MOREHOUSE, H. Preston** (*M* 1933) Gen. Htg. and Air Cond. Repr., Public Service Electric & Gas Co., 80 Park Pl., Newark, N. J.
- MOREHOUSE, J. Stanley** (*M* 1938) Dean of Engrg., Villanova College, Villanova, and 102 Llandoff Rd., Upper Darby, Pa.
- MORGAN, Arthur S.** (*M* 1938) Mgr., Fess Oil Burners of Canada, Ltd., 85 King St. W., and •156 Glenmanow Dr., Toronto, Ont., Canada.
- MORGAN, Edwin H., Jr.** (*J* 1942) Draftsman, Chemical Construction Corp., 30 Rockefeller Plaza, New York, N. Y., and •411 Chestnut St., Roselle Park, N. J.
- MORGAN, Glenn C.** (*M* 1911) Partner, •Morgan-Gerrish Co., 307 Essex Bldg., and 4308 Fremont Ave. S., Minneapolis, Minn.
- MORGAN, Robert C.** (*Life Member; M* 1915) Chairman of the Board, •Stewart A. Jellett Co., 1200 Locust St., and 314 W. Seymour St., Philadelphia, Pa.
- MORGAN, Robert W.** (*M* 1938) Asst. Chief Design Engr., Fedders Manufacturing Co., 57 Tonawanda St., Buffalo, and •71 Highland Dr., Williamsville, N. Y.
- MORIARTY, John M.** (*M* 1937) Owner, •Consolidated Heating & Ventilating Co., 1709 W. Eighth St., Los Angeles, and 1616 Baldwin Ave., Arcadia, Calif.
- MORIN, A. R.** (*A* 1938) Mgr., Refrigeration Dept., Macklamburg Supply Co., Inc., 111 Northwest 23rd, and •2115 Sherman, Oklahoma City, Okla.
- MORRIS, C. Raymond** (*M* 1921) Pres., Power & Heating Equipment Sales, Inc., 56 N. Spring Garden Ave., Nutley, N. J.
- MORRIS, Edward J.** (*M* 1942) Mgr., •Morris Engineering Co., 813 N. Calvert St. and 3414 Gwynn's Fall Pkwy., Baltimore, Md.
- MORRISON, Chester B.** (*M* 1931) Managing Dir., •York Shipley, Ltd., North Circular Rd., Hendon, London, N. W. 2, and Flat 168, 55 Park Lane, London, S. W. 1, England.
- MORRISON, W. Bruce** (*A* 1942; *J* 1939) Asst. Engr., U. S. Engineers, 628 Pittcock Block, and •1805 Northeast 27th Ave., Portland, Ore.
- MORRO, John J.** (*M* 1940) Engr., Paragon Oil Co., 50 Van Dam St., Brooklyn, and •28 East 28th St., New York, N. Y.
- MORROW, J. DeWitt** (*A* 1938) Pres. and Mgr., •The Warren Co., Inc., 614 Walker Ave., and 5503 La Branch St., Houston, Texas.
- MORSE, Clark T.** (*M* 1913) Pres., •American Blower Corp., P. O. Box 58, Roosevelt Park Annex, and 16222 Shaftsbury Rd., Detroit, Mich.
- MORSE, Floyd W.** (*A* 1934) Vice-Pres., •Chamberlain Metal Weather Strip Co., 1254 LaBrosse St., Detroit, Mich., and 132 Villa St., Mt. Vernon, N. Y.
- MORSE, Louis S., Jr.** (*M* 1938; *J* 1936) Lt. (jg), U. S. N. R., and •Lone Pine Rd., Bloomfield Hills, Mich.
- MORSE, Robert D.** (*M* 1936) Mfrs. Repr., •4404 White Bldg., and 4316 East 43rd St., Seattle, Wash.
- MORTON, Harold S.** (*M* 1931) Lt.-Col., Ordnance Dept., U. S. Army, Office of the Chief of Ordnance, Washington, D. C., and •524 Ritchie Ave., Silver Spring, Md.
- MORTON, Paul S.** (*A* 1943; *J* 1939) Htg., Pibg., Sales and Engrs., 609 Bangor Rd., Lawrence, Mich.
- MOSES, Walter B., Jr.** (*J* 1940; *S* 1936) Engr., Pendleton Shipyards Co., Inc., 1800 Masonic Temple Bldg., and •8330 Spruce St., New Orleans, La.
- MOSHER, Clarence H.** (*A* 1919) Owner, C. H. Mosher Co., 423 Ashland Ave., Buffalo, N. Y.
- MOSKOWITZ, Samuel** (*A* 1942) Prop., •American Steam & Oil Heating Co., 4504 Ft. Hamilton Pkwy., and 955-45th St., Brooklyn, N. Y.
- MOTZ, O. Wayne** (*M* 1932) Consulting Engr., •234 Paramount Bldg., and 2605 Briarcliff, Cincinnati, Ohio.
- MOULD, Harry W., Jr.** (*J* 1941) Engr., Fedders Manufacturing Co., Buffalo, and •23 Tremont Ave., Kenmore, N. Y.
- MUCKLE, James** (*M* 1939) Address Unknown—Mail Returned.
- MUELLER, Harold C.** (*M* 1936; *A* 1930) Mgr., •Powers Regulator Co., 2720 Greenwood Ave., Chicago, and 1277 Forest Glen Dr. N., Winnetka, Ill.
- MUELLER, Harold P.** (*M* 1936) Pres., Treas., •L. J. Mueller Furnace Co., 2005 W. Oklahoma Ave., and 511 E. Monrovia Ave., Milwaukee, Wis.
- MUELLER, John E.** (*M* 1937) Mgr. of Commercial Customer Dept., •West Penn Power Co., 14 Wood St., Pittsburgh, and 810 Parkside Dr., Mt. Lebanon, Pa.
- MUENZMAYER, Willard R.** (*A* 1941) Owner, Mgr., Muenzenmayer Sheet Metal Co., Junction City, Kan.
- MUESSIG, James W.** (*M* 1938) Sales Engr., •Clarage Fan Co., 333 N. Michigan Ave., Chicago, and 405 Lodge Lane, Lombard, Ill.
- MURHEID, John G.** (*A* 1940; *J* 1937) •Pvt., Co. "D", 4th Bn. E. R. T. C., Third Platoon, Fort Belvoir, Va., and 1621 Queens Rd., Charlotte, N. C.
- MUNIER, Leon L.** (*M* 1919; *J* 1915) Pres., •Wolf & Munier, Inc., 222 East 41st St., New York, and 63 Columbia Ave., Hartsdale, N. Y.
- MUNKELT, Frederick H.** (*M* 1938) Vice-Pres., •W. B. Connor Engineering Corp., 114 East 32nd St., New York, and 317 East 17th St., Brooklyn, N. Y.
- MURDOCH, John P.** (*M* 1937) Pres., •John P. Murdoch Co., S.W. Cor. 30th and Oakford Sts., Philadelphia, and 735 Beechwood Dr., Beechwood, Pa.
- MURHARD, Erroll A.** (*M* 1939) Pres., Engr. (Civil and Mech.), Muirhead & Murhard Co., 338 S.W. Ninth Ave., and •2136 N.W. Upshur St., Portland, Ore.
- MURPHREE, Robert L.** (*A* 1940; *J* 1936) Engr., Rogers Plumbing & Heating Co., 2127 Eighth St., and •P. O. Box 864, Tuscaloosa, Ala.
- MURPHY, Charles G.** (*M* 1942; *A* 1935) Design Foreman, Mech. and Elec., Wright Aeronautical Corp., Aircraft Engines, Lockland, and •6717 Murray Ave., Mariemont, Ohio.
- MURPHY, Daniel C.** (*A* 1940) Sales Repr., •C. A. Dunham Co., 214 Old Colony Bldg., and 3900 Grand Ave., Des Moines, Iowa.
- MURPHY, Delacour I.** (*M* 1941) Sales Engr., E. C. Cooley Co., 625 Market St., San Francisco, and •3027 Millsbrae Ave., Oakland, Calif.
- MURPHY, Edward T.*** (*M* 1915) Vice-Pres., •Carrier Corp., and 1055 James St., Syracuse, N. Y.
- MURPHY, Eugene F.** (*J* 1942) Instr. Mech. Engr., University of California, Berkeley, Calif.
- MURPHY, Howard C.*** (*M* 1923) Vice-Pres., •American Air Filter Co., 215 Central Ave., and 495 Lightfoot Rd., Louisville, Ky.
- MURPHY, Joseph R.** (*M* 1934; *A* 1925) Vice-Pres., Taco Heaters, Inc., 342 Madison Ave., New York, N. Y., and •Terrace Ave., Riverside, Conn.
- MURPHY, William W.** (*M* 1930) Treas., •W. W. Murphy Co., 424 Worthington St., and 25 Mansfield St., Springfield, Mass.
- MURRAY, H. G. S.** (*M* 1942; *A* 1941; *J* 1936) Sales Engr., •Canadian Comstock Co., Ltd., 80 King St. W., and 19 Elora Rd., Toronto, Ont., Canada.
- MURRAY, Thomas F.** (*M* 1923) Sr. Htg. and Vtg. Engr., Div. of Architecture, New York State Dept. of Public Works, State Office Bldg., and •14 S. Lake Ave., Albany, N. Y.
- MURSINNA, Gilbert P.** (*A* 1939) Htg., Air Cond. Contractor, •Gilbert P. Mursinna, 411 Poplar St., and 3657 Boudinot Ave., Cincinnati, Ohio.
- MUSGRAVE, Merrill N.** (*A* 1935) Owner, •Merrill N. Musgrave & Co., 2019 Third Ave., and 1005 E. Roy St., Apt. 13, Seattle, Wash.

MUSSER, John M. (M 1942) Mech. Engr., U. S. Engineers, 110 E. Garden St., and •530 Turin, Rome, N. Y.
MYER, Haydn (A 1920) Pres., •Haydn Myer Co., Inc., 2224 Comer Bldg., and 1411 Avon Circle, Birmingham, Ala.
MYERS, George W. F. (M 1930; A 1928; J 1923) Myers Engineering Equipment Co., 3800 W. Pine Blvd., St. Louis, and •476 Pasadena Ave., Webster Groves, Mo.
MYLER, William M., Jr.* (M 1937) Chief Engr., •Janitrol Engrg. Dept., Surface Combustion Div. of General Properties Co., Inc., 400 Dublin Ave., and 1545 Grenoble Rd., Columbus, Ohio.

N

NACHMAN, George P. (M 1938) Treas., •The Spohn Heating & Ventilating Co., 1775 Est 45th St., and 2887 Falmouth Rd., Cleveland, Ohio.
NAMAN, Israel A. (J 1940) Mech. Engr., Planning Div., Ventilation Group, Puget Sound Navy Yard, and •P. O. Box No. 46, Bremerton, Wash.
NAROWETZ, Louis L., Jr. (M 1929; A 1912) Pres., •Narowetz Heating & Ventilating Co., 1711-1717 Maypole Ave., Chicago, and 112 S. Northwest Highway, Park Ridge, Ill.
NASS, Arthur F. (M 1927) Pres., •McGinness, Smith & McGinness Co., 527 First Ave., and 29 Elmhurst Rd. (Wabash Station), Pittsburgh, Pa.
NATION, Oslin (J 1942) Assoc. Engr., U. S. Engineering Defense Div., Denison, and •9702 El Patio Dr., Dallas, Texas.
NEAL, James P. (A 1939) Capt., Cincinnati Ordnance Dist., and •Box 154, R. R. 1, Station M., Indian Hill Rd., Cincinnati, Ohio.
NEARINGBURG, Arthur (A 1938) Sales Engr., •Sheldons, Ltd., 1221 Bay St., and 130 Floyd Ave., Toronto, Ont., Canada.
NEE, Raymond M. (M 1936) Mech. Engrg. Administrator, •Chemical Construction Corp., Room 6201, 30 Rockefeller Plaza, and 5 East 82nd St., New York, N. Y.
NEILER, Samuel G. (Life Member; M 1898) Owner, •Neiler Rich & Co., Consulting Mech. & Elec. Engrs., 431 S. Dearborn St., Chicago, and 737 N. Oak Park Ave., Oak Park, Ill.
NELSON, Axel A. (A 1942) Chief Engr., •Federal Reserve Bank Bldg., Federal Reserve P. O. Station, Kansas City, and R. F. D. No. 4, North Kansas City, Mo.
NELSON, D. W.* (M 1928) Assoc. Prof. Mech. Engrg., •College of Engineering, University of Wisconsin, Mech. Engrg. Bldg., and 3906 Council Crest, Madison, Wis.
NELSON, George O. (M 1923) Engr., Carstens Bros., Ackley, Iowa.
NELSON, Harold M. (M 1937) Pres., •H. M. Nelson & Co., Inc., 1223 Connecticut Ave., Washington, D. C., and Falls Church, Va.
NELSON, Herman W. (Life Member; M 1909) Chairman of the Board, •The Herman Nelson Corp., 1824 Third Ave., and 2615-12th St., Moline, Ill.
NELSON, Laurence K. (M 1940) Assoc. Engr., •James M. Todd, Consulting Engr., 624 Gravier St., and 2502 Palmer Ave., New Orleans, La.
NELSON, Richard H. (A 1933; J 1928) Pres., The Herman Nelson Corp., 1824 Third Ave., and •1303-30th St., Moline, Ill.
NELSON, Roy O. (M 1938) Sales Engr., •C.H. Bevington Co., 600 S. Michigan Ave., and 5636 N. Bernard St., Chicago, Ill.
NESBITT, Albert J.* (M 1921) Pres., •John J. Nesbitt, Inc., State Rd. and Rhawn St., Philadelphia, and Babylon and Davis Grove Rds., Hathboro, Pa.
NESMITH, Oliver E. (A 1928) Engr., Williams Oil-O-Matic Heating Corp., Bell and Hanna, and •107 Warner, Bloomington, Ill.
NESS, William H. C. (M 1931) Gen. Mgr., •Master Fan Corp., 1323-35 Channing St., and 215 N. Kingsley Dr., Los Angeles, Calif.
NESSELL, Clarence W. (M 1937) Supvr., Federal Projects Div., Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave. S., Minneapolis, Minn.

NEST, Richard E. (M 1936) Consultant, 5018 Morello Rd., Baltimore, Md.
NEUBAUER, Edwin W. (M 1939) Engr., •Campbell Norquist & Co., 1127 S.W. Morrison St., and 4804 N.E. Davis St., Portland, Ore.
NEWBY, Ira P. (M 1941) in charge of Htg. Sect., 8th Service Command, U. S. Engineers, Santa Fe Bldg., and •6325 Bryan Pkwy, Dallas, Texas.
NEWMAN, Harold E. (M 1938) Asst. Mgr., •B. A. Newman Co., 320 North H St., and 419 Buckingham Way, Fresno, Calif.
NEWPORT, Charles F.* (Life Member; M 1906) Sales Engr., Weil-McLain Co., Michigan City, Ind., and •10001 Longwood Dr., Chicago, Ill.
NEWTON, Alwin B.* (M 1938) Mgr., Refrigeration Controls Div., •Minneapolis-Honeywell Regulator Co., 2747 Fourth Ave. S., and 18 W. Rustic Lodge Ave., Minneapolis, Minn.
NICHOLLS, John M. (M 1939) •Robbins Gamwell Corp., 68 West St., and 136 Bartlett Ave., Pittsfield, Mass.
NICHOLSON, Sterling J. (A 1941) Pres., Nicholson, Inc., Box 317, Durham, N. C.
NICKLE, Arthur J. (A 1936) Sales Engr., •Darling Brothers, Ltd., 140 Prince St., and 4356 Marcell Ave., Montreal, Que., Canada.
NICOLL, Scott F.* (M 1939) Air Cond. Application Engr., •York Ice Machinery Corp., York, and 1433 First Ave., Elmwood, York, Pa.
NICOLS, John A. (M 1941) Mgr., B. F. Sturtevant Co., 910 Essex Bldg., 31 Clinton St., Newark, and •52 Wood Rd., Mountainside, N. J.
NIELSEN, Howard B. (A 1939) 416 Couch Bldg., Portland, Ore.
NIESSE, Joseph H. (M 1938) Indiana Branch Mgr., Iig Electric Ventilating Co., 836 Architects & Builders Bldg., and •5837 Winthrop Ave., Indianapolis, Ind.
NIGHTINGALE, George F. (A 1931) 2136 Linneman St., Glenview, Ill.
NOBBS, Walter W. (M 1919) Consulting Engr., 26 Victoria St., London, S. W. 1, and •50 Fairhazel Gardens, London, N. W. 6, England.
NOBIS, Harry M. (M 1914) Owner, •Nobis Heater Co., 1935 Union Commerce Bldg., Cleveland, and 1827 Stanwood Rd., East Cleveland, Ohio.
NOBLE, Milner (M 1940; A 1929; J 1924) Gen. Mgr., Aerofin Corp., 410 S. Geddes, Syracuse, N. Y.
NOLAN, James J., Jr. (M 1939) Sr. Mech. Engr., War Dept., Office of Quartermaster General, and •4024 Calvert St. N.W., Washington, D. C.
NOLL, William F. (M 1924) Prop., •Wm. F. Noll, 629 North 27th St., and 4823 W. Townsend St., Milwaukee, Wis.
NOORD, Donald F. (J 1941; S 1935) 268 E. Main St., Frostburg, Md.
NORRAIR, Henry (M 1938) Pres., •Norair Engineering Corp., 1114-22nd St. N.W., and 5908 32nd St. N.W., Washington, D. C.
NORBY, Karl H. (A 1938) Mgr. Htg. Dept., Tacoma Plumbing Supply Co., 315 South 23rd St., Tacoma, and •Box 113, Parkland, Wash.
NORDINE, Louis F. (M 1914) Office Mgr., The Trane Co., 2701 Ontario Rd. N.W., Washington, D. C., and •812 Silver Springs Ave., Silver Spring, Md.
NORFOLK, Leslie W. (A 1941; J 1939) Major, Royal Engrs., H. M. Forces, F. H. Q., Gibraltar, and •42 Hampden St., Nottingham, England.
NORMAN, Roy A. (M 1937) Prof. of Mech. Engrg., Iowa State College, Mech. Engrg., Dept., and •715 Ridgewood Ave., Ames, Iowa.
NORRINGTON, Walter L. (A 1943; J 1938) Capt., Ordnance Dept., Office of Chief of Ordnance, Washington, D. C., and •305 Barbara Fritchie, Beverly Plaza, Alexandria, Va.
NORRIS, William P. (J 1938) •U. S. Engineer Office, Room 611, Santa Fe Bldg., and 1714 Avenue F, Galveston, Texas.
NORTE, Wilbur R. (J 1942) Industrial Sales Crane Co., 532 Eighth Ave. S., Nashville, Tenn.
NORTH, Clarence P. (M 1942) Chief Engr., Campbell Heating Co., and •3614 E. Seventh St., Des Moines, Iowa.

ROLL OF MEMBERSHIP

NORTH, Samuel L. (A 1942) Partner, •North Bros., 442 Cain St. N.E., and 107 Peachtree Hills Ave. N.E., Atlanta, Ga.
NORTH, William R. (A 1940) Sales Engr., •27 S. Gay St., and 1521 Kingsway Rd., Baltimore, Md.
NORTON, John A. (M 1940) Mgr. Htg. Sales Div., Crane, Ltd., 306 Front St. W., Toronto, and •136 Hanna Rd., Leaside, Ont., Canada.
NORTON, L. Ivan (A 1941) Engr., •Evo-ready Plumbing & Heating Co., 211 S. Iowa Ave., and 110 E. Polk St., Washington, Iowa.
NOTTBERG, Gustav (A 1933) Vice-Pres., •U. S. Engineering Co., 914 Campbell St., and 1835 East 68th Terrace, Kansas City, Mo.
NOTTBERG, Henry (M 1919) Pres., •U. S. Engineering Co., 914 Campbell St., and 150 West 54th St., Kansas City, Mo.
NOTTBERG, Henry, Jr. (J 1937) Secy., •U. S. Engineering Co., 914 Campbell St., and 150 West 54th St., Kansas City, Mo.
NOWITZKY, Herman S. (A 1931) Supt. Construction, Wilmer & Vincent Corp., 1776 Broadway, New York, N. Y., and •821 Llewellyn Ave., Norfolk, Va.
NOYES, Richard R. (J 1938) Field Engr., •Canadian Sirocco Co., Ltd., 630 Dorchester St. W., and 5552 Queen Mary Rd., Apt. 4, Montreal, Que., Canada.
NUSBAUM, Lee* (M 1915) Owner, •Pennsylvania Engineering Co., 1119-21 N. Howard St., Philadelphia, and 315 Carpenter Lane, Germantown, Philadelphia, Pa.
NUSBAUM, S. Richard (J 1940) Mgr., •Pennsylvania Engineering Co., 1119-21 N. Howard St., Philadelphia, and 552 Montgomery Ave., Haverford, Pa.
NUTTING, Arthur* (M 1940) Chief Engr., •American Air Filter Co., Inc., 215 Central Ave., and 4040 Ormond Rd., Louisville, Ky.
NYE, L. Bert, Jr. (A 1943; J 1936) Laboratory Supvr., Washington Gas Light Co., 1100 H St. N.W., Washington, D. C., and •McLean, Va.
NYQUIST, John D. (J 1942; S 1941) Development Engr., Collins Radio Co., 835-35th St., and •1535 Bever Ave., Cedar Rapids, Iowa.

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OKALEY, LeRoy W. (M 1937) Owner, •L. W. Oakley Sales Co., 408 W. Clinch Ave., and 2003 Laurel Ave., Knoxville, Tenn.
OAKS, Orion O. (M 1917) Consulting Mech. Engr., 511 Fifth Ave., New York, N. Y., and •119 Oakridge Ave., Summit, N. J.
O'BANNON, Lester S.* (M 1928) Research Engr., •Agricultural Experiment Station, University of Kentucky, and 123 State St., Lexington, Ky.
OBORG, H. C. (A 1933) Mgr. Engrg. Dept., Crane Co., Fifth and Broadway, and •1362 W. Minnehaha St., St. Paul, Minn.
OBERLIN, James A. (J 1942; S 1940) Engr., •Allied Products Corp., Plant 3, and 211 Union St., Hillsdale, Mich.
OBERSCHULTE, Richard H. (J 1938) Sales Engr., •D. T. Randall & Co., 404 Blvd. Bldg., Detroit, and Box 76, Franklin, Mich.
O'CONNELL, Thomas D'Arcy (A 1942) Pres., •Thomas O'Connell, Ltd., 1169 Ottawa St., and 1505 Mountain St., Montreal, Que., Canada.
O'DANIEL, James A. (M 1942) Mgr., •Maple City Furnace Co., 603 S. Main St., and 617 S. Main St., Monmouth, Ill.
O'DOWER, Hugh J. (A 1938) Sales Engr., •Vilter Manufacturing Co., 114 W. Tenth St., and 6844 Locust, Kansas City, Mo.
ODUM, Ralph A. (A 1939) R. 1, Box 173, Holly Hill, Fla.
OLGOETZ, J. F. (M 1938) Owner, •J. F. Olgoetz Co., 3365 N. High St., and 279 E. North Broadway, Columbus, Ohio.
OSTERLE, Arthur L. (M 1940) Engr., •Gulf Engineering Co., Inc., 916 S. Peters St., and 3420 Live Oak Pl., New Orleans, La.

OFFEN, Ben (M 1928) •B. Offen & Co., 608 S. Dearborn St., and 5555 Sheridan Rd., Chicago, Ill.
OFFNER, Alfred J.* (M 1922) (Treas., 1935-38; Council, 1935-42) Consulting Engr., •139 East 53rd St., New York, and 160-15 11th Ave., Beechhurst, L. I., N. Y.
O'GORMAN, J. S., Jr. (A 1934) Branch Mgr., •Johnson Service Co., 230 E. Alexandrine Ave., Detroit, and 147 Abbey Rd., Birmingham, Mich.
OLD, William H. (M 1937) Asst. Mgr., •Glanz & Killian, 1761 Forest Ave. W., Detroit, and 18245 Devonshire Rd., R. F. D. No. 4, Birmingham, Mich.
OLSEN, Carlton F. (A 1925; J 1920) Engr. and Sales, Kewanee Boiler Corp., 549 W. Washington Blvd., and •1000 West 100th St., Chicago, Ill.
OLSEN, Gustav E. (M 1930) Sales Mgr., Fitzgibbons Boiler Co., Inc., 101 Park Ave., New York, and •68-09 Beach Channel Dr., Arverne, L. I., N. Y.
OLSON, Barney (A 1929) •Barney Olson, Inc., 122 S. Michigan Ave., and 5724 N. Natoma Ave., Chicago, Ill.
OLSON, Eugene O. (M 1942) Asst. Prof., •Iowa State College, Engineering Extension Service, and 804 Tenth St., Ames, Iowa.
OLSON, Gilbert E. (M 1930) Southern Mgr., •H. K. Ferguson Co., 1605 Commerce Bldg., and 3359 Park Pl. Blvd., Houston, Texas.
OLSON, Milton J. (A 1941; J 1937) Vice-Pres., Olson Bros., 2651-55 St. Mary's Ave., and •5627 Williams St., Omaha, Nebr.
OLSON, Robert G. (M 1923) Eastern Mgr., •Hydraulic Coupling Div., American Blower Corp., 50 West 40th St., and 108 East 38th St., New York, N. Y.
OLVANY, William J. (Life Member; M 1912) Pres., Wm. J. Olvany, Inc., 100 Charles St., New York, N. Y.
O'NEILL, James W. (M 1929; A 1927; J 1925) Chief Engr., Trane Company of Canada, Ltd., 4 Mowat Ave., and •55 Highview Crescent, Toronto, Ont., Canada.
OONK, W. J. (M 1937) Dist. Engr., B. F. Sturtevant Co., 915 Olive St., and •4548 Red Bud Ave., St. Louis, Mo.
OOSTEN, Louis S. (J 1938) Engr., Bell & Gossett Co., 8200 Austin Ave., Morton Grove, and •1827 Berwyn Ave., Chicago, Ill.
OREAR, Andrew G. (M 1942; A 1930) Pres., •Trade-Wind Motorfans, Inc., 5725 S. Main St., Los Angeles, and 1015 E. Raleigh St., Glendale, Calif.
O'REAR, L. R. (M 1934) Pres., •Midwest Plumbing & Heating Co., 2450 Blake St., and 825 S. Josephine St., Denver, Colo.
ORGELMAN, George H. (J 1942; S 1940) Construction Engr., Turner Construction Co., 420 Lexington Ave., New York, N. Y., and •3324 Latimer Ave., Ashtabula, Ohio.
ORMISTON, John B. (A 1940) Owner, •Ormiston Plumbing & Heating Co., 105 Manning Ave., and 1 Gramatan Dr., Yonkers, N. Y.
OSBORN, Wallace J. (A 1927) Vice-Pres., Keeney Publishing Co., 1734 Grand Central Terminal Bldg., New York, N. Y., and •1029 Old Post Rd., Fairfield, Conn.
OSBORNE, G. H. (M 1922) Managing Dir., The Ventilating & Blow Pipe Co., Ltd., 714 St. Maurice St., and •836 Pratt Ave., Outremont, Montreal, Que., Canada.
OSBORNE, Stanley R. (M 1939) Development Engr., •Chase Brass & Copper Co., Grand St., Waterbury, and 115 Grove St., Naugatuck, Conn.
O'SHEA, John J. (A 1941) Sales Repr., Buffalo Forge Co., 305 Teckwood Dr. N.E., and •714 Greenville Ave. N.E., Atlanta, Ga.
OSTER, William P. (M 1940) Vice-Pres. Engrg. Service Div., •Equitable Equipment Co., Inc., 410 Camp St., and 4651 Baccich St., New Orleans, La.

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- OSTROM, Eric W.** (M 1937) Chief Engr., Air Cond. Dept., A/B Svenska Flakfabriken, Kungsgatan 16, and • John Ericssonsgatan 18, Stockholm, Sweden.
- OTT, M. Earl** (M 1942) Pres., Parkside Sheet Metal Works, Inc., 7445 S. Chicago Ave., Secy., Treas., Lakeside Metal Service, Inc., 23 East 115th St., and • 8635 S. Wabash Ave., Chicago, Ill.
- OTT, Oran W.** (M 1925) (Council, 1934-36) Consulting Mech. Engr., • 606 Washington Bldg., Los Angeles, and 1462 Waverly Rd., San Manno, Calif.
- OTTO, Robert W.** (M 1912) Mech. Engr., Toltz, King & Day, Inc., 1509 Pioneer Bldg., and • 2147 Carroll Ave., St. Paul, Minn.
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- POLLAK, Rudolf** (M 1937) Chief Engr., •Rockefeller Center, Inc., 50 Rockefeller Plaza, New York, and 140 Palmer Ave., Larchmont, N. Y.
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- REICH, Julius G.** (A 1941) Chief Engr., Sales Engr., •The Holland Furnace Co., 12700 Superior Ave., and 10703 Lee Ave., Cleveland, Ohio.
- REID, Henry P.** (M 1931; A 1927) Asst. to Pres., Universal Atlas Cement Co., 135 East 42nd St., Chrysler Bldg., New York, N. Y.
- REID, Herbert F.** (A 1932) Partner, Htg. Dept., •Reid-Graff Co., 1417 Peck St., and 1552 Maffett St., Muskegon Heights, Mich.
- REIF, Allan T.** (M 1937) Colonel, 74th Inf. Regt., and •10 Livingston Pkwy., Snyder, N. Y.
- REIF, Charles A.** (M 1937) Vice-Pres., •Reif-Rexoil, Inc., 37 Carroll St., Buffalo, and 77 Ruskin Rd., Eggertsville, N. Y.
- REIFSCHNEIDER, Jake** (A 1938) Chief Engr., •Eppley Hotels Co., 1802 Dodge St., and 4409 Roppleton, Omaha, Nebr.
- REILLY, Bertram B.** (J 1938) Engr., •Dravo Corp., 300 Penn Ave., Pittsburgh, and 220 Ridge Ave., Ben Avon, Pa.
- REILLY, Philip H., Jr.** (A 1941) Secy., Treas. and Production Mgr., •Heating Equipment Co., 1123 Harrison St., San Francisco, and 1321 Vancouver Ave., Burlingame, Calif.
- REINKE, Alfred G.** (A 1940; J 1933) Secy., Gus Reinke Machinery & Tool Co., 63 Dickenson St., Newark, and •321 Park Pl., Irvington, N. J.
- REINKE, Louis F.** (A 1937) Owner, •Reinke Sheet Metal Works, 534 S. Fifth St., and 1535 W. Walker St., Milwaukee, Wis.
- REIS, Robert** (J 1939) Mech. Engr., •Wigton Abbott Corp., 1225 South Ave., and 713 Watchung Ave., Plainfield, N. J.
- REISBERG, Lester K.** (M 1942; A 1939) Vice-Pres., Goodin Co., 615 N. Third St., and •2724 N.E. Hayes St., Minneapolis, Minn.
- REPP, Harry L.** (M 1922); •U. S. Radiator Corp., 402 Swetland Bldg., Euclid Ave., Cleveland, and 14611 Clifton Blvd., Lakewood, Ohio.
- RESCH, Roy J.** (A 1940) Pres., •McQuay Inc., 1600 Broadway N.E., and 3725 Glenhurst Ave., St. Louis Park, Minneapolis, Minn.
- RETTEW, Harvey F.** (M 1929) Chief Engr., Board of Education, School Dist. of Philadelphia, 21st and Parkway, and •4912 Osage Ave., Philadelphia, Pa.
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- REYNOLDS, Thurlow W.** (M 1922) Consulting Engr., and •100 Pinecrest Dr., Hastings-on-Hudson, N. Y.
- REYNOLDS, Walter V.** (A 1928) Pres., •Walter Reynolds, Inc., 861 Third Ave., New York, and 80 Boulevard, Scarsdale, N. Y.
- RHEAULT, Walter E.** (M 1942) 1st Lt., C. E., U. S. Army •325th Engr. Bn. (c), A. P. O. 100, Ft. Jackson, S. C., and 2246 Orchard St., Racine, Wis.
- RHINE, George R.** (A 1938) Major, Ordnance Dept., Asst. Port Ordnance Officer, New York Port of Embarkation, and •8801 Shore Rd., Brooklyn, N. Y.
- RHOTON, W. R.** (M 1936) Vice-Pres., The W. R. Rhoton Co., 5915 Bonna Ave., Cleveland, and •1728 Lee Rd., Cleveland Heights, Ohio.
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- RICE, Robert B.** (M 1934) Exec. Officer, Mech. Engrg. Dept., •North Carolina State College, and 2502 White Oak Rd., Raleigh, N. C.
- RICHARD, Edwin J.** (M 1933) Owner, •Richard Equipment Co., 2137 Reading Rd., and 3147 Victoria Ave., Cincinnati, Ohio.
- RICHARDS, Guy H.** (A 1939) Mgr. Htg. Dept., Crane Co., 2 South 20th St., and •7230 First Ave. S., Birmingham, Ala.
- RICHARDS, Leslie V.** (M 1941; A 1940) Owner-Mgr., •Richards Oil Burner Sales & Service, 97 Lawrence St., Malden, Mass.
- RICHARDSON, Henry G.** (M 1934) Pres., Williams-Richardson Co., and •1433 Harvard Ave., Salt Lake City, Utah.
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- RIETZ, Elmer W.** (M 1923) Mgr. Specialty Div., •The Powers Regulator Co., 2720 Greenview Ave., Chicago, and 2250 S. Sheridan Rd., Highland Park, Ill.
- RILEY, John N.** (M 1942) Lt. (jg), E-V (s) U. S. N. R., c/o Supervisor of Shipbuilding, and •4327 S.E. Ash St., Portland, Ore.
- RINK, Charles N.** (M 1942) Mgr. Coil Div., McQuay Inc., 1600 Broadway N.E., and •4802 Emerson St., Minneapolis, Minn.
- RISLEY, George H.** (A 1941) Mgr., •Cole Draft Governor Co., 801 S.W. Stark St., Portland, and R. No. 10, Box 382, Milwaukee, Ore.
- RITCHIE, A. G.** (M 1933) Pres., •John Ritchie, Ltd., 102 Adelaide St. E., and 41 Garfield Ave., Toronto, Ont., Canada
- RITCHIE, Edmund J.** (M 1923) Vice-Pres., Sales, Sarco Co., Inc., 475 Fifth Ave., New York, and •2 Grace Court, Brooklyn, N. Y.
- RITTELMAYER, John M.** (M 1941) •Rittelmeyer & Co., 405 Bona Allen Bldg., and 2332 Woodward Way, Atlanta, Ga.
- RITTENHOUSE, Owen R.** (J 1943; S 1941) Foreman, Inspection Dept., Saginaw Steering Gear Div. of General Motors, Plant No. 2, Holmes St., and •1003 Court St., Saginaw, Mich.
- RITTER, Arthur** (M 1911) Mgr. New York Office, •American Blower Corp., 50 West 40th St., New York, and 29 Edgemont Rd., Scarsdale, N. Y.
- RIVARD, M. M.** (M 1935) Mgr., Rivard Sales Co., 4550 Main St., and •1805 West 49th St. Terrace, Kansas City, Mo.
- ROACH, Edwin R.** (A 1941) Htg. and Vent. Engr., Engineer Board, Fort Belvoir, and •724 S. St., Asaph St., Apt. 108-A, Alexandria, Va.
- ROBB, Joseph E.** (A 1936) Sales Engr., Minneapolis-Honeywell Regulator Co., Minneapolis, and •1717 Illinois St., Lawrence, Kan.
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- ROBERTS, Henry P.** (A 1936) 3142 W. Lake Calhoun Blvd., Minneapolis, Minn.
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- ROBIN, Richard C.** (A 1941) Section Leader, General Electric Co., 920 Western Ave., Lynn, and •Hartford St., Natick, Mass.
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- ROGERS, Charles S.** (A 1940) Lt. (jg), U.S.N.R., and •304 Maple Ave., Falls Church, Va.
- RONICK, Edward H.** (M 1937) Suprv., Gas Htg. Sales, •St. Louis County Gas Co., 231 W. Lockwood Ave., Webster Groves, and 7739 Stanford, University City, Mo.
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- ROSE, Howard J.** (M 1934) Pres., Gen. Mgr., Consolidated Conditioning Corp., 10 Brookdale Pl., Mt. Vernon, and •100 Norman Rd., New Rochelle, N. Y.
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ROWLEY, Frank B.* (M 1918) (*Presidential Member*) (Pres, 1932; 1st Vice-Pres., 1931; 2nd Vice-Pres., 1930; Council, 1927-33) Prof. Mech. Engrg., and Dir. of Engineering Experiment Station, and Head of Mech. Dept., University of Minnesota, Minneapolis, and •Excelsior, Minn.

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RUMMEL, Adolph J.* (M 1937) Asst. Mgr., Commercial Dept., •San Antonio Public Service Co., 201 N. St. Mary's St., and 235 North Dr., San Antonio, Texas.

RUMSEY, John L. (M 1941) Chief Htg. and Plbg. Engr., Macnsons Contractors, Naval Supply Depot, Clearfield, and •35 Hill Villa Circle, Layton, Utah.

RUSSELL, Boyd A. (A 1941) Air Conditioning Testing Engr., Baker, Smith & Co., Inc., War Dept., Pentagon Bldg., Washington, D. C., and •10210 Pierce Dr., Silver Spring, Md.

RUSSELL, Edward A. (M 1936) Chief Engr., Vapor Car Heating Co., Inc., 1600 S. Kilbourn Ave., and •8103 Dorchester Ave., Chicago, Ill.

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RUSSELL, William A. (M 1921) (Council, 1934-39, 1941-42) Southwestern Zone Mgr., •Hoffman Specialty Co., 1229 Union Ave., and 444 West 58th St., Kansas City, Mo.

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S

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- SALZER, Alfred R., Jr.** (J 1940) Mech. Engr., Government Construction, and •1923 N. Claiborne Ave., New Orleans, La.
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- SANDERS, Charles M., Jr.** (J 1938) 2nd Lt., •Signal Corps, Electronics Training Group, Section 116-B A. P. Area Ft. Monmouth, and Shrewsbury, N. J.
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- SANFORD, Sterling S.*** (M 1930) Sales Engr., •The Detroit Edison Co., 2000 Second Ave., and 1503 Seyburn Ave., Detroit, Mich.
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- SAURWEIN, George K.** (M 1938) Major (Plant Engr.), Ordnance, U. S. Army, Watertown Arsenal, Watertown, and •247 Slade St., Belmont, Mass.
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- SCHAFER, Harry C.** (M 1937) Sales Mgr., Iroquois Gas Corp., 45 Church St., Buffalo, and •197 Union St., Hamburg, N. Y.
- SCHAUER, Robert A.** (J 1942) Htg. and Air Cond. Engr., •Westinghouse Electric & Manufacturing Co., Raff Rd. S.W., and 3205 Engle Pl. S.W., Canton, Ohio.
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- SCHURMAN, John A., Jr.** (M 1936; J 1935) Sales Engr., York Ice Machinery Corp., 2700 Washington Ave., Cleveland, and •16307 Lakewood Heights Blvd., Lakewood, Ohio.
- SCHUSTER, Paul H.** (A 1942) Chief Htg. Inspector (War Dept.), c/o Post Engrs., Camp Chaffee, and •110 North 20th St., Ft. Smith, Ark.
- SCHWARTZ, Jacob** (A 1936; J 1929) Contractor, •Samuel Schwartz & Son, Inc., 30 West 27th St., Bayonne, and 12 Van Houten Ave., Jersey City, N. J.
- SCHWARTZ, Maurice** (A 1938) Supvr., Queensborough Gas & Electric Co., and •780 Caffrey Ave., Far Rockaway, L. I., N. Y.

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- SCOFIELD, Paul C.** (A 1937; J 1933) Sr. Design Engr., Lockheed Aircraft Corp., Burbank, and •425 E. Randolph, Glendale, Calif.
- SCOTT, George M.** (*Life Member*; M 1915) Pres., Child & Scott-Donohue, Inc., 153 East 38th St., New York, and •24 Bramhall Ave., Scarsdale, N. Y.
- SCOTT, Roy M.** (A 1941) Mgr., Roy M. Scott, •323 Tenth St., and 35 Fairfield Way, San Francisco, Calif.
- SCOTT, William P., Jr.** (M 1941; J 1939) Vice-Pres., Scott Co., 243 Minna St., and •255 Santa Paula Ave., San Francisco, Calif.
- SEARLE, William J., Jr.** (M 1938) Air Conditioning Engr., 110 Woodside Ave., Narberth, Pa.
- SECKINGER, Benjamin J., Jr.** (M 1941) Vice-Pres., •Seckinger Sons Co., Inc., 180 Forsyth St. S.W., and 1110 Lanier Blvd. N.E., Atlanta, Ga.
- SEEBER, R. R.*** (M 1934) Prof. Mech. Engrg. Dept., Michigan College of Mining & Technology, Houghton, Mich.
- SEELBACH, Herman, Jr.** (A 1937) Dist. Mgr., •Minneapolis-Honeywell Regulator Co., 45 Allen St., Buffalo, and 186 Union St., Hamburg, N. Y.
- SEELBACH, William R.** (A 1942) Pres., •Equipment Sales, Inc., 800 Erie County Bank Bldg., Buffalo, and Windowver, Hamburg, N. Y.
- SEELERT, Edward H.** (A 1935) Secy.-Treas., McQuay Inc., 1600 Broadway N.E., and •2927 Ulysses St. N.E., Minneapolis, Minn.
- SEELEY, Lauren E.*** (M 1930) Assoc. Prof. of Mech. Engrg., •Mason Laboratory, Yale University, New Haven, and 1856 Whitney Ave., Hamden, Conn.
- SEELIG, Lester** (M 1925) Development Engr., U. S. Rubber Co., 6600 E. Jefferson Ave., and •17206 Pennington Dr., Detroit, Mich.
- SEGLE, Thomas L.** (A 1942) Sales Engr., Wells & Wade, Inc., and •819 S. Chelan Ave., Wenatchee, Wash.
- SEITER, J. Earl*** (M 1928) Asst. Mgr. of New Business Dept., •Consolidated Gas, Electric Light & Power Co., Lexington Bldg., Room 500, and 7117 Bristol Rd., Stoneleigh, Baltimore, Md.
- SELDEN, Karl W., Jr.** (A 1942) Dist. Repr., •Minneapolis-Honeywell Regulator Co., 701 Builders Bldg., and 232 S. Torrence St., Charlotte, N. C.
- SELF, V. Floyd** (M 1941) Sales Engr., •Anemostat Corporation of America, 10 East 39th St., New York, and 615 Harrison Ave., Harrison, N. Y.
- SELIG, Ernest T., Jr.** (M 1936) Chief Mech. Engr., •Black & Veatch, Box 12, Pando, and Glenwood Springs, Colo.
- SELLMAN, Nils T.** (M 1922) Asst. Vice-Pres., •Consolidated Edison Company of New York, Inc., 4 Irving Pl., New York, and 58 Walworth Ave., Scarsdale, N. Y.
- SELTZER, Paul A.** (A 1943; J 1938) Engr., Bryant Air Conditioning Corp., 915 N. Front St., Philadelphia, and •154 E. Marshall Rd., Lansdowne, Pa.
- SEMEL, Edward** (A 1943; J 1941) Htg. Engr., Huffman Wolfe Co., 4660 North 18th St., and •6029 Ellsworth St., Philadelphia, Pa.
- SEVERNS, William H.*** (M 1933) Prof. Mech. Engrg., •University of Illinois, and 609 Indiana Ave., Urbana, Ill.
- SEYFANG, William G.** (M 1939) Managing Engr., Div. of Plants, •Board of Education, 814 City Hall, and 116 Dorchester Rd., Buffalo, N. Y.
- SEYMOUR, James E.** (A 1937) Prop., •Lee & Seymour, 346 Russell St., and 208 Lakewood Blvd., Madison, Wis.
- SGAMBATI, Anthony P.** (S 1939) 3 Spencer St., Youngstown, Ohio.
- SHAER, I. Ernest** (A 1934) Treas. and Sales Mgr., •Shaer & Turner Engineering Co., 88 Broad St., Boston, and 154 Seaver St., Roxbury, Mass.
- SHAFER, W. P., Jr.** (J 1941; S 1939) Asst. Engr., U. S. Engineers, Ft. Sam Houston, and •210 Encino Ave., San Antonio, Texas.
- SHAFFER, Chester E.** (M 1937) Research Engr., •Koppers Co., Kearny, and 645 Belgrove Dr., Arlington, N. J.
- SHANKLIN, Arthur P.** (M 1929) Vice-Pres. and Regional Mgr., •Carrier Corp., 20 N. Wacker Dr., Chicago, and 45 Green Bay Rd., Winnetka, Ill.
- SHANKLIN, John A.** (M 1928) Vice-Pres. and Treas., •West Virginia Heating & Plumbing Co., 233 Hale St., and 1507 Quarrier St., Charleston, W. Va.
- SHAPIRO, Charles A.** (A 1943; J 1938) Lt., U. S. N. R., Missouri Valley Bridge & Iron Co., Evansville, Ind.
- SHAPIRO, Morris** (M 1941) Sr. Mech. Engr., Federal Public Housing Authority, Tech. Div., and •6323 Luzon Ave. N.W., Washington, D. C.
- SHARP, Henry C.** (M 1935) Product Application Engr., •The Herman Nelson Corp., 6625 Delman Blvd., St. Louis, and 7442 Melrose Ave., University City, Mo.
- SHARP, John R.** (A 1937) Major, C. E., •c/o 104th Engr. Bn., A. P. O. 44, Ft. Lewis, Wash., and Maple St., Haworth, N. J.
- SHAW, Burton E.*** (A 1936; J 1934) Research Chief, •Penn Electric Switch Co., Goshen, and Bristol, Ind.
- SHAW, John A.** (M 1938) Gen. Elec. Engr., •Canadian Pacific Railway Co., Room 900, Windsor St. Station, Montreal, and 448 Lansdowne Ave., Westmount, P. Q., Canada.
- SHAW, N. J. H.** (M 1927; J 1925) Sales Engr., Barnes & Jones, Inc., 128 Brookside Ave., Jamaica Plain, and •87 Benjamin Rd., Arlington, Mass.
- SHEA, Michael B.** (M 1921) Registered Engr., Sales Dept., •American Radiator & Standard Sanitary Corp., 1426 Maccabee Bldg., and 3214 Carter St., Detroit, Mich.
- SHEARER, William A., Jr.** (J 1941; S 1939) 2nd Lt., Engr. Corps, Fort Leonard Wood, Mo., and •407 Sixth Ave., New Kensington, Pa.
- SHEARS, Matthew W.** (M 1922) Engr., •C. A. Dunham Co., Ltd., 1523 Davenport Rd., and 39 Sylvan Ave., Toronto, Ont., Canada.
- SHEFFIELD, Raymond A.** (M 1937) Owner, •Air Conditioning Engineering Co., 90 Memorial Dr., Cambridge, and 92 Governor Winthrop Rd., Somerville, Mass.
- SHEFFLER, Morris** (M 1921) Partner, •Sheffler-Gross Co., Inc., Drexel Bldg., Philadelphia, and 419 Chapel Rd., Melrose Park, Montgomery Co., Pa.
- SHELBY, Alexander W.** (M 1942) Partner of Firm •Shelby-Skipwith, Inc., 678 Union Ave., and 1748 Vinton, Memphis, Tenn.
- SHELDON, Nelson E.** (M 1927) Branch Mgr., •Carrier Corp., S. Geddes St., Syracuse, and 41 Lanark Crescent, Rochester, N. Y.
- SHELDON, Robert W.** (A 1942) Sales Engr., •The Lake Shore Gas Co., 226 Progress Pl., and 1512 East 47th St., Ashtabula, Ohio.
- SHELDON, William D., Jr.** (A 1936; J 1934) Chief Engr., Sheldon's, Ltd., •Cedar St., Galt, Ont., Canada.
- SHELEY, Earle D.** (M 1937) Pres., •Glanz & Killian Co., 1761 W. Forest Ave., Detroit, and Box 243, Birmingham, Mich.
- SHELL, Jack** (M 1940) Engr., Air Cond. Dept., Jefferson Amusement Co., Box 3191, and •2575 11th St., Beaumont, Texas.
- SHELLDROD, Tonn F.** (M 1942) Design Engr., Parsons, Klapp, Brinckerhoff & Douglas, 142 Maiden Lane, New York, and •8000 Fourth Ave., Brooklyn, N. Y.
- SHEPARD, Carl R.** (M 1941) Inspection Engr. (M.E.), U. S. Public Bldgs. Admn., 1108 Latham Square Bldg., and •438 Rich St., Oakland, Calif.
- SHEPARD, John deB.** (M 1937; J 1929) Air Cond. Engr., •Consolidated Gas, Electric Light & Power Co., Lexington Bldg., Room 505, and 4823 Keswick Rd., Baltimore, Md.

- SHEPPARD, Frank A.** (M 1918) Sales, • Johnson Service Co., 1031 Wyandotte St., and 27 East 70th St., Kansas City, Mo.
- SHEPARD, Wallace K.** (M 1942) Supvr. of Htg. Sales • The Peoples Natural Gas Co., 545 William Penn Way, and 6420 Darlington Rd., Pittsburgh, Pa.
- SHEPPERD, Parker D.** (A 1940; J 1938) Branch Mgr., • Johnson Service Co., 608 Masonic Temple Bldg., and 17 Metairie Court, New Orleans, La.
- SHERBROOKE, Walter A.** (M 1938) Grinnell Co., 29-50 Northern Blvd., Long Island City, and • 92 Twombly Ave., Bay Terrace, Staten Island, N. Y.
- SHERET, Andrew** (Life Member; M 1920; A 1925) Pres., • Andrew Sheret, Ltd., 1114 Blanshard St., and 1030 St. Charles St., Victoria, B. C., Canada.
- SHERMAN, Ralph A.*** (M 1933) Supvr., Fuels Div., • Battelle Memorial Institute, 505 W. King Ave., and 1893 Coventry Rd., Columbus, Ohio.
- SHERMAN, Victor L.** (M 1935) Consulting Mech. Engr., and • 643 Hillside Ave., Glen Ellyn, Ill.
- SHERMAN, W. P.** (M 1937) Chief Engr., • T. Louis Murray Co., 1807 Main St., and 1802 Pendleton St., Columbia, S. C.
- SHERWOOD, Laurence T.** (M 1937) Glass Technologist, • Pennsylvania Wire Glass Co., Fayette Co., Dunbar, and 11 Angle St., Connellsville, Pa.
- SHIRE, A. C.** (M 1942) Technical Dir., • Federal Public Housing Authority, Longfellow Bldg., and 3015 Dumbarton Ave., Washington, D. C.
- SHORE, David*** (J 1938) Htg. and Vent. Design, New York Shipbuilding Corp., Camden, N. J., and • 4101 Spruce St., Apt. 412, Philadelphia, Pa.
- SHORT, William W.** (A 1942) Sales Engr., • Anemostat Corporation of America, 10 East 39th St., and 541 West 113th St., New York, N. Y.
- SHROCK, John H.** (M 1924) Vice-Pres., New York Blower Co., and • 2026 Indiana Ave., LaPorte, Ind.
- SHULTZ, Earle** (A 1919) Vice-Pres., • Illinois Maintenance Co., 72 W. Adams St., and 5555 Sheridan Rd., Chicago, Ill.
- SHUMAN, Laurence** (M 1939) Mech. Engr., Federal Public Housing Authority, Region III, 19th and D St., Washington, D. C., and • 8387 16th St., Silver Spring, Md.
- SIEGEL, Daniel E.** (J 1940; S 1938) Giffels & Vallet, Inc., 1000 Marquette Bldg., and • 2980 Elmhurst, Detroit, Mich.
- SIEGEL, Roy C.** (A 1939) Owner • International Chimney Co., 303 Curtiss Bldg., and 243 Norwalk Ave., Buffalo, N. Y.
- SIEMON, Herbert B.** (M 1942) Branch Mgr., Holland Furnace Co., 604 Cherokee, Leavenworth, and • 2604 West 68th St., Rt. No. 2, Mission, Kan.
- SIGMUND, Ralph W.** (M 1932) Dist. Mgr., • B. F. Sturtevant Co., 913 Provident Bank Bldg., and 130 Wm. H. Taft Rd., Cincinnati, Ohio.
- SILBERSTEIN, Bernard G.** (M 1937) Dist. Mgr., • Ilg Electric Ventilating Co., 622 Broadway, and 814 E. Mitchell Ave., Cincinnati, Ohio.
- SILVERA, Americo** (A 1943; J 1939) Engr., Carrier Corp., International Div., Syracuse, N. Y.
- SIMKIN, Milton** (A 1942; J 1936; S 1933) Engr., Buensod-Stacey Air Conditioning, Inc., 60 East 42nd St., New York, N. Y., and • 111 Brighton Ave., Perth-Amboy, N. J.
- SIMMS, Herman** (J 1942) Draftsman (Head of Drafting Dept.), York Ice Machinery Corp., 412 Houston St. N.E., and • 863 Ponce de Leon Ave. N.E., Atlanta, Ga.
- SIMONS, Byron C.** (M 1938) Branch Mgr., • Minneapolis-Honeywell Regulator Co., 3033 Locust Blvd., St. Louis, and 20 Orchard Ave., Webster Groves, Mo.
- SIMONS, Edward W.** (M 1938) Chief Mech. Engr., Redwood Manufacturers Co., and Caspar Lumber Co., 1600 Hobart Bldg., and • 40 Villa Terrace, San Francisco, Calif.
- SIMONSON, George M.** (M 1937) Consulting Engr., • 625 Market St., Room 309, San Francisco, and 20 Lorita Ave., Piedmont, Calif.
- SIMPSON, G. L.** (M 1941) Vice-Pres.-Gen. Mgr., • Pittsburgh Lectrodryer Corp., P. O. Box 1766, Pittsburgh, and 317 Pine Rd., Edgeworth, Pa.
- SIMPSON, Robert L.** (J 1941) Lt. (jg), U.S.N.R., and • 9 Sands St., Waterbury, Conn.
- SIMPSON, William K.** (M 1919) Engr. Consultant, 9 Sands St., Waterbury, Conn.
- SKAGERBERG, Rutchter** (M 1924; J 1921) Sr. Mech. Engr., Federal Public Housing Authority, Longfellow Bldg., Washington, D. C., and • 420 Tyler Pl., Alexandria, Va.
- SKINNER, Alton, Jr.** (J 1940) Htg. and Air Cond. Engr., • J. R. Bagwell Co., 320 Holland St., and 1202 Vickers Ave., Durham, N. C.
- SKINNER, Henry W.** (M 1920) Mech. Engr., Austin Co., 4816 Dexter, Fort Worth, Texas.
- SLAWSON, Lloyd E.** (A 1938) Mgr., Temperature Control Dept., • Barber-Colman Co., 3030 Euclid Ave., Cleveland, Ohio, and Rockford, Ill.
- SLEMMONS, John D.** (M 1937) Mgr. Sales Office, • American Blower Corp., 666 Marion Rd., Columbus and Rte. 2, Wilson Rd., Worthington, Ohio.
- SLOANE, David J.** (J 1943; S 1939) U. S. Army, 56th General Hospital, Fort Jackson, S. C.
- SMAK, Julius R.** (A 1934) Fletcher-Thompson, Inc. Architects and Engrs., 211 State St., Bridgeport, and • 160 Morehouse Highway, Fairfield, Conn.
- SMALL, Bartlett R.** (M 1938; A 1937; J 1932) Staff Engr., • Aluminum Company of America, 801 Gulf Bldg., and 34 Hillman St. (10), Pittsburgh, Pa.
- SMALL, Ray A.** (M 1941) Mech. Engr., • Dept. of Agriculture, 28 V St. N.W., Washington, D. C., and 227 N. Third St., Lewisburg, Pa.
- SMILES, Roy H.** (M 1941) Dealer Supvr., • Carrier Corp., 12 South 12th St., and 5936 N. Seventh St., Philadelphia, Pa.
- SMITH, Clifford F., Jr.** (J 1943; S 1941) Ensign, Planning Div., Puget Sound Navy Yard, and 100 Anaha Ave., Bremerton, Wash.
- SMITH, David J.** (J 1941) Sales Engr., • Walter H. Eagan Co., 2336 Fairmount Ave., Philadelphia, and 524 Mercer Rd., Merion Park, Pa.
- SMITH, Elmer G.*** (M 1929) Prof. of Physics, • Agricultural and Mechanical College of Texas, Dept. of Physics, and 100 Fairview Ave., College Station, Texas.
- SMITH, Gard W.** (M 1927) Sales Engr., Premier Furnace Co., 1131 Guilford St., Huntington, Ind.
- SMITH, George E.** (A 1942) Supvr. Engr., Ministry of Works & Planning, 67/68 Jermyn St., No. 1 West Ave., Pinner, Middlesex, England.
- SMITH, Gerald E.** (J 1938) Royal Canadian Engineers • 52 Parkway Ave., Toronto, Ont., Canada.
- SMITH, Harold C.** (M 1941) Partner • The Smith-White Co., 1102 Commerce Trust Bldg., and 5840 Olive St., Kansas City, Mo.
- SMITH, Milton S.** (M 1919) Vice-Pres. and Gen. Mgr., • Buensod-Stacey Air Conditioning, Inc., 60 East 42nd St., New York, N. Y., and 13 N. Terrace, Maplewood, N. J.
- SMITH, Nelson J.** (M 1938) Air Cond. Design Engr., • Frigidaire Div., General Motors Sales Engr., Taylor and Monument Ave., and 1332 Riverview, Dayton, Ohio.
- SMITH, Roger C.** (A 1940) Asst. to Branch Engr., York Ice Machinery Corp., 119 S. Eleventh St., St. Louis, and • 7040 Tulane Ave., University City, Mo.
- SMITH, Roger K.** (M 1942) Instructor in Mech. Engrg., • Iowa State College, Mech. Engrg. Dept., and 2031 Country Club Blvd., Ames, Iowa.
- SMITH, Sidney T.** (J 1941) Htg. Engr., Sid Smith & Co., 411 W. Fifth St., and • 609 Moir, Waterloo, Iowa.

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- SMITH, Stuart** (A 1936) Asst. Mgr., American Radiator & Standard Sanitary Corp., 1747 Connecticut Ave., Washington, D. C., and •6922 Fairfax Rd., Bethesda, Md.
- SMITH, Walter H.** (M 1939) Chief Engr., •The T. Eaton Co., Ltd., 10 Louisa St., and 7 Kingscourt Dr., Toronto, Ont., Canada.
- SMITH, Wilbur F.** (M 1920) Consulting Engr., W. M. Anderson Co., 600 Schuylkill Ave., Philadelphia, and •709 Braeburn Lane, Penn Valley, Narberth P. O., Pa.
- SMITH, William O.** (A 1937) Pres., •Smith Automatic Heat Service, Inc., 19250 John R St., Detroit, and 7 Sylvan Rd., Pleasant Ridge, Mich.
- SMITH, William P., Jr.** (J 1942) Estimator and Engr., •The A. Z. Price Co., Inc., 225 Piedmont Bldg., and 1808 Kenwood Ave., Charlotte, N. C.
- SMOOT, Charles B.** (M 1942) Chief Engr. of Southern Region •Carrier Corp., 348 Peachtree St. N.E., and 892 Adair Ave. N.E., Atlanta, Ga.
- SMOOT, T. H.** (M 1935) •Room 108, Maryland Hall, Johns Hopkins University, and 1302 Southview Rd., Baltimore, Md.
- SMYERS, Edward C.** (A 1933) Sales Engr., Barber-Colman Controls, 1013 Penn Ave., Wilkensburg, and •148 Jamaica Ave., West View, Pittsburgh, Pa.
- SNARELY, A. Bowman** (M 1937) Chief Engr., Hershey Chocolate Corp., Hershey, Pa.
- SNARELY, Earl R.** (M 1937) Sales Mgr., •Instrument Div., Thomas A. Edison, Inc., West Orange, and Parkway Dr., R. F. D. No. 1, Clark, N. J.
- SNOOK, Alfred H.** (A 1940) Mfrs. Agent, Wayland, Mich.
- SNYDER, Edwin F., Jr.** (J 1940) 2nd Lt., C. of E., U. S. Army, U. S. Engr. Dept., Keesler Field, Miss., and •308 Courtland St., Dowagiac, Mich.
- SNYDER, Jay W.** (M 1917) Member of Firm, •Snyder & McLean, 2214 Penobscot Bldg., and 8987 Martindale Ave., Detroit, Mich.
- SNYMAN, G. C.** (A 1941) Executive Co-ordinator, Bell Aircraft Corp., Niagara Falls Plant, and •Apt. 7, Red Coach Inn, Niagara Falls, N. Y.
- SOBEL, Frank** (S 1939) Private, •Co. A, 101 M. P. Bn., Fort Dix, N. J., and 115 Post Ave., New York, N. Y.
- SOCKWELL, Charles, Jr.** (A 1942) Partner, Sockwell Co., 156 Rogers St. N.E., and •2562 Boulevard Dr. N.E., Atlanta, Ga.
- SOCKWELL, Charles, Sr.** (M 1942) Partner, •Sockwell Co., 156 Rogers St. N.E., Atlanta, and 5447 Roswell Rd., Dunwoody, Ga.
- SOCKWELL, Tyrus R.** (A 1942) Partner, •Sockwell Co., 156 Rogers St. N.E., and 5385 Peachtree-Dunwoody Rd., Rte. No. 6, Atlanta, Ga.
- SODEMANN, William C. B.** (M 1919) Pres., •Sodemann Heat & Power Co., 2306 Delmar Blvd., St. Louis, and 7542 Teasdale Ave., University City, Mo.
- SOLSTAD, Lester L.** (J 1936) Htg. Engr., Austin Sheet Metal Works, 5109 W. Chicago, and •5348 W. Potomac, Chicago, Ill.
- SOMMERFIELD, Sumner S.** (A 1941; J 1936) 4106 N. Keystone Ave., Chicago, Ill.
- SOMMERS, William J.** (M 1937) Sales Repr., •Ilg Electric Ventilating Co., 505 Delaware Ave., Buffalo, and 235 Hartford Ave., Kenmore, N. Y.
- SOMERS, William S.** (M 1938; A 1928; J 1926) Vice-Pres. in charge of Production, Lameck Products, Inc., and •113 Kenwood Dr., Middletown, Ohio.
- SOPER, Horace A.** (M 1916) Pres., •American Foundry & Furnace Co., Washington at McClun, and 1122 E. Monroe St., Bloomington, Ill.
- SOULE, John P.** (J 1942) Mech. Engr., Federal Shipbuilding & Drydock Co., 744 Broad St., Newark, and •Gordon Rd., Essex Fells, N. J.
- SOULE, Lawrence C.*** (Life Member; M 1908) Secy. and Consulting Engr., Aerofin Corp., Syracuse, N. Y., and •Gordon and Stewart Rds., Essex Fells, N. J.
- SOUTHMAYD, R. T.** (J 1936) Sales, American Blower Corp., 611 Akron Savings & Loan Bldg., Akron, Ohio.
- SPALL, Edward G.** (A 1939) Sales Engr., Powellite Devices, Ltd., Penn Electric Switch Div., 171 John St., and •291 Windermere Ave., Toronto, Ont., Canada.
- SPARKS, James D.** (A 1937) Northwest Repr., Ilg Electric Ventilating Co., 7331 W. Green Lake Way, Seattle, Wash.
- SPECKMAN, Charles H.** (Life Member; M 1918) •Consulting Htg. and Vtg. Engr., 482 Bourse Bldg., and 1217 S. Fourth, Philadelphia, Pa.
- SPELLER, Frank N.*** (Life Member; M 1908) Metallurgical Consultant, 6411 Darlington Rd., Pittsburgh, Pa.
- SPENCE, Morton R.** (A 1942; J 1934) Vice-Pres., •Rundle & Spence Manufacturing Co., 445 N. Fourth St., and 709 E. Lexington Blvd., Milwaukee, Wis.
- SPENCE, Robert A.** (J 1937) Lt., Ordnance Dept., U. S. Army, Boston Ordnance Dist., 140 Federal St., Boston, and •33 Barnard Rd., Belmont, Mass.
- SPENCER, Roland M.** (A 1940; J 1934) Priorities Mgr., The Powers Regulator Co., 2720 Greenview Ave., and •7315 Lunt Ave., Chicago, Ill.
- SPENCER, Warner E.** (A 1938) Repr., National Radiator Co., Inc., 220 Delaware Ave., Buffalo, N. Y.
- SPIELMANN, Gordon P.** (A 1931; J 1923) Owner, •Harrison-Spielmann Co., 480 Milwaukee Ave., Chicago, and 730 N. Prospect Ave., Park Ridge, Ill.
- SPIETH, Benjamin** (M 1941) Chief Engr., •Modine Manufacturing Co., and 400 Harvey Dr., Racine, Wis.
- SPITZLEY, Joseph H.** (J 1939) Engr., •R. L. Spitzley Heating Co., 1200 W. Fort St., and 1415 Parker Ave., Detroit, Mich.
- SPITZLEY, R. L.** (M 1920) Pres., •R. L. Spitzley Heating Co., 1200 W. Fort St., Detroit, and 26 Renaud Rd., Grosse Pointe Shores, Mich.
- SPOERR, Frank F.** (A 1942; J 1937) Carrier Corp., Marine Div., Chrysler Bldg., New York, and •8915-182nd Pl., Jamaica, L. I., N. Y.
- SPOFFORTH, Walter** (M 1930) Chief of Mech. Services, Federal Penitentiary, McNeil Island, and •615 N. Ainsworth, Tacoma, Wash.
- SPROTT, John I.** (A 1941) Sales, •Ray Oil Burner Co., 401 Bernal Ave., and 10 Parker Ave., San Francisco, Calif.
- SPROULL, Howard E.** (M 1920) Div. Sales Mgr., •American Blower Co., 1005-6 American Bldg., and 3588 Raymar Dr., Cincinnati, Ohio.
- SPURGEON, Joseph H.** (M 1924) Mfrs. Agent, •Spurgeon Co., 5050 Joy Rd., and 17215 Pennington Dr., Detroit, Mich.
- SPURNEY, Felix E.** (A 1938) Engr., Turner Construction Co., and •28 W. Baltimore St., Kensington, Md.
- STACEY, Alfred E., Jr.*** (M 1914) (Council, 1941-42) Comdr., U. S. Navy, and •35 Wootton Rd., Essex Fells, N. J.
- STACK, Arthur E.** (A 1935) Asst. Mgr. of Utilization Dept., Washington Gas Light Co., 11th and H Sts. N.W., Washington, D. C., and •7911 Chicago Ave., Silver Spring, Md.
- STACY, L. David** (A 1936) Sales Engr., Ilg Electric Ventilating Co., 222 N. LaSalle St., Chicago, and •303 Elmhurst Rd., Prospect Heights, Ill.
- STACY, Stanley C.** (M 1931) Mech. Engr., •Board of Education, 13 S. Fitzhugh St., and 340 Monroe Ave., Rochester, N. Y.
- STAFFORD, J. Fuller** (A 1938) Owner, 519 N. Snelling Ave., St. Paul, and •4545-18th Ave. S., Minneapolis, Minn.
- STAFFORD, Thomas D.** (A 1937) Vice-Pres.-Mgr., •Alexander-Stafford Corp., 1 Ionia Ave. N.W., and 954 Ogden Ave. S.E., Grand Rapids, Mich.
- STAHL, Walter A.** (M 1938) Properties Mgr., Montgomery Ward & Co., 618 W. Chicago Ave., Chicago, and •2504 Harrison St., Evanston, Ill.

- STAMMER, Edward L.** (*Life Member; M 1919*) Supt. Htg. and Vtg. Repairs, St. Louis Board of Education, Board of Education Bldg., and •4430 Tennessee Ave., St. Louis, Mo.
- STANDING, Ronald A.** (*A 1942; J 1938*) Htg. Engr., •Gurney Foundry Co., Ltd., 100 Principal St., Ville St. Laurent de Montreal, and 2358 Leclaire St., Maisonneuve, Montreal, Que., Canada.
- STANGER, R. B.** (*M 1920*) Prop., •Robinson & Stanger, Empire Bldg., Pittsburgh, and Middle Rd., Glenshaw, Pa.
- STANGLE, William H.** (*M 1940*) Servel, Inc., Evansville, Ind., and •255 Benita, Youngstown, Ohio.
- STANLEY, Robert L.** (*M 1938*) Engr., Factory Repr., •Pacific Gas Radiator Co., 7631 Roseberry Ave., Huntington Park, and 2518 Dearborn Dr., Los Angeles, Calif.
- STANTON, Harold W.** (*M 1938*) Commercial Sales Dir., •Iowa-Nebraska Light & Power Co., and 2100 Ryons St., Lincoln, Nebr.
- STARK, W. E.*** (*M 1926*) (Council, 1932-36) Mgr. Stoker Div., The Bryant Heater Co., 17825 St. Clair Ave., Cleveland, and •1875 Rosemont Rd., East Cleveland, Ohio.
- STASZESKY, Francis M.** (*J 1942; S 1938*) Student (Co-Op), Boston Edison Co., •Mass. Inst. of Tech. Dorms, Cambridge, Mass. (from October to June), and 10 Roselawn Ave, Roselle, Wilmington, Del.
- STECKHAN, Louis** (*M 1928; J 1926*) Sales Engr., •Crane Co., 30 South 16th St., and 3240 Liberty St., St. Louis, Mo.
- STEEL, R. Justin** (*A 1938*) Lt., U. S. N. R., •Bureau of Ships, Navy Dept., Washington, D. C., and 346 S. College Ave., Newark, Del.
- STEELE, J. B.** (*M 1932*) Chief Engr., •Winnipeg School Board, Ellen and William Ave., Winnipeg, and 184 Waterloo St., Riverheights, Winnipeg, Man., Canada.
- STEFNER, Edward F.** (*A 1937; J 1934*) Htg. Engr., The Henry Furnace & Foundry Co., 3471 East 49th St., Cleveland, and •1429 East 133rd St., East Cleveland, Ohio.
- STEGGALL, Howard B.** (*M 1942; A 1934*) Branch Mgr., U. S. Radiator Corp., 941 Behan St., and •1166 Murray Hill Ave., Pittsburgh, Pa.
- STEIN, Jerome** (*J 1942; S 1940*) Secy., Torrington Supply Co., Inc., 125 Maple St., and •756 Waterville St., Waterbury, Conn.
- STEINHORST, T. F.** (*M 1919*) Pres., Emil Steinhorst & Sons, Inc., 612 South St., Utica, N. Y.
- STEINKE, Bernard J.** (*J 1940; S 1937*) Mech. Design Engr., U. S. Navy Yard, Public Works Div., Brooklyn, N. Y., and •Railroad Ave., River Edge, N. J.
- STEINMETZ, C. W. A.** (*M 1934*) Office Mgr., •Sales Engineering & Business Management, American Blower Corp., 249 High St., Newark, and 50 Oakwood Ave., Bogota, N. J.
- STELLWAGEN, Frank G.** (*A 1937*) Sales Engr., 8637-77th St., Woodhaven, L. I., N. Y.
- ST. LAURENT, Guy** (*A 1942*) Plbg. and Htg. Contr., •Hector Groulx, Engr., 1638 Notre Dame St. W., and 8381 Drolet St., Montreal, Que., Canada.
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- TUSCH, Walter** (M 1917) Secy., Tenney & Ohmes, Inc., 101 Park Ave., New York, and • 881 Sterling Pl., Brooklyn, N. Y.
- TUTHILL, Arthur F.*** (J 1940; S 1938) Instructor Mech. Engr., • The Cooper Union, Mech. Engrg. Dept., Cooper Square, New York, and 62 Montague St., Brooklyn, N. Y.
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- TUTT, Richard D.** (J 1942) Air Cond. Engr., Allison Div., General Motors Corp., Speedway City, and • 5845 Haverford Ave., Indianapolis, Ind.
- TUTTLE, G. H.*** (M 1937; A 1936; J 1934) Htg. Engr., • The Detroit Edison Co., 2000 Second Ave., and 16714 Kentfield, Detroit, Mich.
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- TUVE, George L.*** (M 1932) (Council, 1939-41) Prof. of Heat Power Engr., • Case School of Applied Science, 10900 Euclid Ave., Cleveland, and 2510 Newbury Dr., Cleveland Heights, Ohio.
- TUXHORN, David B.** (M 1936) Mgr., The York Heat & Fuel Co., 1419 Eye St. N.W., and • 4853 Sedgwick St. N.W., Washington, D. C.
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- TWIZZELL, Edwin W.** (M 1937) Partner, • Connolly & Twizell Reg'd., 1405 Bishop St., Montreal, and 22 Merton, Crescent, Hampstead, Que., Canada.
- TYDINGS, Wm. F.** (M 1942) Owner, • Tydings Engineering Co., 16395 Lahser Rd., and 26540 Lyndon Rd., Detroit, Mich.
- TYLER, Roy D.** (M 1928) Chief Mech. Engr., • New Facilities & D. P. C. Section, U. S. Army, Boston Ordnance Dist., 140 Federal St., and 20 Pinckney St., Boston, Mass.

U

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- UPSON, Walter L.** (M 1938) Dir. of Research, • The Torrington Manufacturing Co., Torrington, and Litchfield, Conn.
- URBAN, Frank F.** (A 1939) Vice-Pres., Urban Plumbing & Heating Co., 1215 S. W. Fifth Ave., and • 6726 S. W. Burlingame Ave., Portland, Ore.
- URDAHL, Thomas H.** (M 1930) (Council, 1940-42) Lt.-Comdr. E-V (s), U. S. N. R., and • 1505 44th St. N.W., Washington, D. C.
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V

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- VAUGHAN, Lillian L.** (M 1938) Prof. of Mech. Engrg., Acting Dean, School of Engrg., • North Carolina State College, and 11 Enterprise St., Raleigh, N. C.
- VERNON, Rex** (M 1928; A 1926) • Johnson Service Co., 507 E. Michigan St., Milwaukee, and 710 Oakland Ave., Waukesha, Wis.
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- VIDALE, Richard** (M 1935) Mech. Engr., • Flesch & Schmitt, Inc., 118 Brown St., and 92 Harding Rd., Rochester, N. Y.
- VINCENT, Paul J.** (M 1931) Owner, • Paul J. Vincent Co., 2208 Maryland Ave., and 202 St. Martins Rd., Baltimore, Md.
- VINSON, Neal L.** (J 1936; S 1932) Supvr. of Ventilation, Installation, Shipbuilding, Bethlehem Shipbuilding Co., San Francisco, and • 256 Miller Ave., Mill Valley, Calif.
- VIRRILL, George A.** (A 1940) Chief Engr., The University Club, 1-3 West 54th St., New York, and • 345 Washington Ave., New Rochelle, N. Y.
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- VOISINET, Walter E.** (M 1930) • Laboratory Supt., Curtiss-Wright Corp., Airplane Div., Research Laboratory, Genesee St., Buffalo, and 151 Warren Ave., Kenmore, N. Y.
- VOLK, George H.** (J 1942; S 1940) Vice-Pres., Thomas E. Hoyer Heating Co., 1906 W. St. Paul Ave., and • 2965 South 43rd St., Milwaukee, Wis.
- VOLK, Joseph H.** (M 1923) Pres. and Treas., • Thos. E. Hoyer Heating Co., 1906 W. St. Paul Ave., and 2965 South 43rd St., Milwaukee, Wis.
- VOLKHARDT, Aquila N.** (M 1938) Owner, • A. N. Volkhardt, 942 Bay St., and 104 Townsend Ave., Staten Island, N. Y.
- VOLLMANN, Carl W.** (M 1938) Pres., Gen.-Mgr., • Linde Canadian Refrigeration Co., 355 St. Peter St., Montreal, and 517 Roslyn Ave., Westmount, Que., Canada.
- von REIHERG, Hugo L.** (M 1942) Consulting and Sales Engr., Braman Dow & Co., 239 Causeway St., Boston, and • 11 Parkton Rd., Jamaica Plain, Mass.
- von ROSENBERG, Paul C.** (J 1939) Sales Engr., • Allegheny Engineering Co., 248 Fourth Ave., and 1930 Wightman St., Pittsburgh, Pa.
- VOORHEES, Guy A.** (M 1922) Chief Engr., Hall-Neal Furnace Co., 1324 N. Capitol Ave., and • 3451 Broadway, Indianapolis, Ind.
- VROOME, Albert E.** (M 1932) Air Cond. Engr., • Ebasco Services, Inc., 2 Rector St., New York, and 6218 Amboy Rd., Prince Bay, Staten Island, N. Y.

W

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- WAECHTER, Herman P.** (A 1930; J 1927) Mech. Engr., United Merchants & Manufacturers Management Corp., 601 West 26th St., New York, and • 89 Sherman Ave., Staten Island, N. Y.
- WAGGONER, Jack H.** (M 1937) Product Control Supvr., Owens-Corning Fiberglas Corp., and • 240 Quentin Rd., Newark, Ohio.
- WAGNER, Earle Keller** (M 1938) Sales Engr., • The Powers Regulator Co., 2240 N. Broad St., Philadelphia, and 312 Myrtle Ave., Cheltenham, Pa.
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- WAID, Glen H.** (A 1930) Dist. Sales Mgr., Scott Valve Manufacturing Co., 3903 McKinley Ave., and • 2928 Northwestern Ave., Detroit, Mich.
- WALDEN, H. Kenneth** (A 1942; J 1939) C. S. F., U. S. N. R., 48th Battalion, Company C. H., Platoon 1, Camp Endicott, Davisville, R. I., and • 512 Sixth St. S.W., Birmingham, Ala.
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- WALDREP, James E.** (A 1943; J 1939) Mech. Engr., J. E. Sirrine & Co., Engrs., S. Main St., and • 21 Mt. Vista Ave., Greenville, S. C.
- WALFORD, Leslie C. A.** (M 1938) Joint Inspection Board of United Kingdom and Canada, McGill Bldg., 908 G St. N.W., Washington, D. C.
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- WALKER, J. Herbert*** (M 1916) (2nd Vice-Pres., 1941; Council, 1925; 1938-41) Engr. Asst. to Gen. Mgr., • The Detroit Edison Co., 2000 Second Ave., Detroit, and 432 Arlington Rd., Birmingham, Mich.
- WALKER, Wythe F.** (A 1941) Htg. Engr., Douglas Aircraft, Long Beach, and • 3637 Sixth Ave., Los Angeles, Calif.
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- WALTERS, Arthur L.** (M 1926; A 1925, J 1924) Chief Engr., •Green Colonial Furnace Co., 322 S.W. Third St., and 719-33rd St., Des Moines, Iowa.
- WALTERS, William T.** (M 1917) Mech. Inspector, Bldg. Dept., Illinois Central Railroad, 135 East 11th St., and •12747 Wallace St., Chicago, Ill.
- WALTERTHUM, John J.** (A 1922) Htg. and Vtg. Contr., 212 East 58th St., New York, N. Y., and •42½ Van Reipen Ave., Jersey City, N. J.
- WALTON, Charles W., Jr.** (M 1934) Engrg. Staff, U. S. Rubber Corp., 1230 Sixth Ave., New York, N. Y., and •120 Monte Vista Ave., Ridgewood, N. J.
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- WANGSGAARD, Dee** (A 1942) Proprietor •Wangsgaard Coal & Stoker Co., 167 S. Main St., and 225 E. Second St., Logan, Utah.
- WARD, Frank J.** (M 1935) Owner, •Frank J. Ward Co., 237 W. Court St., Cincinnati, Ohio, and Cold Spring, Ky.
- WARD, O. G.** (M 1919) Vice-Pres., •Johnson Service Co., 1355 Washington Blvd., Chicago, and 1845 Ashland Ave., Wilmette, Ill.
- WARDELL, Arthur** (M 1935) Asst. Prof. of Engrg. Drawing, University of Toronto, and •124 Melrose Ave., Toronto, Ont., Canada.
- WARE, John H., III** (M 1937) Vice-Pres., Citizens Gas & Fuel Co., Pres., Oxford Co., Vice-Pres., Gas Oil Products, Inc., Pres., Oxford Cabinet Co., Vice-Pres., Oxford Furniture Co., Vice-Pres., Delaware Assoc., Inc., •45 S. Third St., and "The Woods," Oxford, Pa.
- WARNER, Cecil F.*** (J 1941) Instructor, •Purdue University, Dept. of Mech. Engrg., and 314 W. Lutz Ave. West Lafayette, Ind.
- WARREN, F. C.** (M 1934) Mgr., Grand Rapids Office, •American Blower Corp., 200 N. Division Ave., and 329 Gladstone Ave. S.E., Grand Rapids, Mich.
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- WARREN, Robert M., Jr.** (A 1943; J 1938) Aviation Cadet, U. S. Army, Meteorology, A. A. F. T. D., Holman Hall, M. I. T., Cambridge, Mass., and •313 N. Main St., Sumter, S. C.
- WASHINGTON, Laurence W.** (M 1929) Dist. Mgr., •The Powers Regulator Co., 702 American Bldg., and 1627 Northwood Dr., Cincinnati, Ohio.
- WASSON, Robert A.** (M 1938) Eastern Dist. Mgr., •Clarage Fan Co., 500 Fifth Ave., New York, and 15 Willow St., Brooklyn, N. Y.
- WATERFALL, Wallace** (M 1941) Dir. Research Engrg., The Celotex Corp., 120 S. LaSalle St., Chicago, Ill.
- WATERMAN, John Howard** (M 1931) Engr., Charles T. Main, Inc., 201 Devonshire St., Boston, Mass.
- WATERS, G. G.** (M 1931; A 1926) Dist. Mgr., •American Blower Corp., 1841 Oliver Bldg., and 110 Longuevue Dr., Pittsburgh (16), Pa.
- WATKINS, George B.** (A 1936) Dir. of Research, •Libby-Owens-Ford Glass Co., 1701 E. Broadway, Technical Bldg., and 4941 Rolandale Rd., Box 227, R. R. 8, Toledo, Ohio.
- WATSON, Gerald M.** (S 1941) Pvt., Hdq. Btry., 94th Div. Artillery, Camp Phillips, Kan.
- WATSON, William W.** (A 1942) Mfrs. Agent, •2970 W. Grand Blvd., Detroit, and 149 N. Main St., Clarkston, Mich.
- WATT, Robert D.** (A 1943; J 1937) Pres., Electrol Oil Burner Corp., Aurora at Mercer, and •3617 47th N.E., Seattle, Wash.
- WATTS, Albert E.** (A 1937) Mgr., A. E. Watts, 637 Craig St. W., and •3788 Hampton Ave., N. D. G., Montreal, Que., Canada.
- WAY, William J., II** (J 1941) Partner, Way Engineering Co., 1901 Carolina St., and •2321 Dryden Ave., Houston, Texas.
- WAYLAND, Clarke E.** (A 1937) Vice-Pres. and Chief Engr., •Western Asbestos Co., 675 Townsend St., and 42 Allston Way, San Francisco, Calif.
- WEATHERBY, Edward P. Jr.** (A 1943; J 1936; S 1935) 2nd Lt., 0-325054, 418 Signal Co., Aviation 8th Fighter Command, A. P. O. 887, c/o Postmaster, New York, N. Y.
- WEAVER, J. v. O.** (M 1940) Lt.-Col. A. C., Chief, Mfg. Methods Section, •Production Div. Materiel Center, Wright Field, and 321 Lomsdale, Oakwood, Dayton, Ohio.
- WEBB, Ernest C.*** (M 1935) Engrg. Service Mgr., •Iron Fireman Manufacturing Co., 3170 West 106th St., Cleveland, and 24721 West Lake Rd., Bay Village, Ohio.
- WEBB, John W.** (M 1926) Managing Dir., •Webb Dust Removing & Drying Co., Vinery Works, Town Lane, Denton, N. Manchester, and "Ebor," Brinnington, Stockport, England.
- WEBBER, Charles H.** (A 1940) Sales Engr., •Pacific Scientific Co., 1430 Grande Vista Ave., Los Angeles, and 1176 Mt. Lowe Dr., Altadena, Calif.
- WEBER, Erwin L.** (M 1921) Consulting Engr., 534 Medical Arts Bldg., Seattle, Wash.
- WEBER, Eugene F., Jr.** (A 1940; J 1937) Application Engr., York Ice Machinery Corp., 117 South 11th St., St. Louis, and •607 Forest Court, Clayton, Mo.
- WEBSTER, Chester C.** (A 1940) Pres., •John Hankin & Brother, 120 Greenwich St., New York, and Box 192, Piermont, N. Y.
- WEBSTER, E. Kessler** (M 1915) Secy.-Asst. Gen. Mgr., •Warren Webster & Co., 17th and Federal Sts., Camden, and First and Kings Highway, Haddon Heights, N. J.
- WEBSTER, Warren, Jr.** (M 1932; J 1927) Pres.-Treas., •Warren Webster & Co., 1625 Federal St., Camden, and 108 Colonial Ridge Dr., Haddonfield, N. J.
- WEBSTER, William H., Jr.** (M 1942; A 1935) Pres. (Engr.), •Allied Heating Products Co., Inc., 2706 Colley Ave., and 200 N. Shore Rd., Academy Terrace, Norfolk, Va.
- WECHSBERG, Otto** (M 1932) Pres.-Gen. Mgr., •Coppus Engineering Corp., 344 Park Ave., and 28 Lenox St., Worcester, Mass.
- WEDDELL, George O.** (M 1936) Branch Mgr., York Ice Machinery Corp., 7 Ferry St., and •3114 Wainbell Ave., Dormont, Pittsburgh, Pa.
- WEEKES, Roy W.** (M 1941) Gas Htg. Engr., Iowa City Light & Power Co., Iowa City, Iowa, and •640 Washington Rd., Apt. L, Pittsburgh, Pa.
- WEGMANN, Albert** (M 1918) Sheet Metal Contractor, A. Wegmann Co., 2801-7 W. Susquehanna Ave., and •6206 North 17th St., Philadelphia, Pa.
- WEIL, F. H. Eugene** (A 1938) Sales Engr., Young Radiator Co., Racine, and •2515 North 59th St., Milwaukee, Wis.
- WEIL, Leo S.** (M 1940) Consulting Engr., •Leo S. Weil & Walter B. Moses, 425 S. Peters St., and 478 Broadway, New Orleans, La.
- WEIL, Martin** (A 1925) Vice-Pres., •Weil-McLain Co., 641 W. Lake St., and 4259 Hazel St., Chicago, Ill.
- WEIMER, Fred G.** (A 1919) Mgr., •Kewanee Boiler Corp., 312 E. Wisconsin Ave., Room 502, and 3958 N. Stowell Ave., Milwaukee, Wis.
- WEINERT, Fred C.** (A 1937) Sales Promotion Mgr., •Chamberlin Metal Weather Strip Co., Inc., 1254 Labrosse St., Detroit, and 9909 Auburndale Ave., Rte. No. 4, Plymouth, Mich.
- WEINSHANK, Theodore*** (Life Member; M 1906) (Board of Governors, 1913) Consulting Engr., 2419 Kimball Ave., Chicago, Ill.
- WEISS, Arthur P.** (M 1928) Burnham Boiler Corp., Irvington, and •134 Farrington Ave., North Tarrytown, N. Y.

- WEISS, Carl A.** (M 1936; A 1924) Vice-Pres., • Kornbrodt Kormice Co., 1811 Troost Ave., and 29 East 68th St., Kansas City, Mo.
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- WEITZEL, Paul H.** (A 1942; J 1936; S 1934) Draftsman, Armstrong Cork Co., and • 335 College Ave., Lancaster, Pa.
- WELCH, Louis A., Jr.** (A 1929) Owner, • Welch Bros., 443 Second St., and 2001 Campbell Ave., Schenectady, N. Y.
- WELDY, Lloyd O.** (M 1930) Dist. Mgr., • The Powers Regulator Co., 2012 West 25th St., Cleveland, and 19623 Laurel Ave., Rocky River, Ohio.
- WELLS, Donald E.** (M 1942) Sales Repr., Globe Machinery & Supply Co., E. First and Court Ave., and • 701-42nd St., Des Moines, Iowa.
- WELLS, Edward E.** (M 1941) Gen. Engrg. Dept., Aluminum Company of Canada, 620 Sun Life Bldg., Montreal, and • 6 St. John Rd., Pointe Claire, Que., Canada.
- WELLS, Earl P.*** (M 1938) Sales Engr., Gay Engineering Corp., 2730 East 11th St., Los Angeles, and • 1133 Graynold Ave., Glendale, Calif.
- WELLS, William F.*** (M 1939) Dir. Lab. for Study of Air-Borne Infection, • University of Pennsylvania, Medical School, Philadelphia, and 112 Pine Ridge Rd., Media, Pa.
- WENDT, Edgar F.** (M 1918) Pres., • Buffalo Forge Co., 490 Broadway, and 120 Lincoln Pkwy., Buffalo, N. Y.
- WENDT, Edwin H.** (A 1942; J 1936) Engr., • O. A. Wendt Co., 2124 N. Southport Ave., and 4728 N. Lawndale Ave., Chicago, Ill.
- WEKKER, Herwart** (M 1939) Engr., American Radiator & Standard Sanitary Corp., Institute of Thermal Research, 675 Bronx River Rd., and • 38 Loring Ave., Yonkers, N. Y.
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- WESLEY, Ray O.** (A 1937) • U. S. Radiator Corp., 334 Boren Ave. N., Seattle, and Yarrow Point, Bellevue, Wash.
- WEST, C. H., Jr.** (A 1941) Vice-Pres., • Massey, Wood & West, Inc., Lombardy Underpass, and 1602 Confederate Ave., Richmond, Va.
- WEST, Perry*** (Life Member; M 1911) (Treas., 1924-25) (Council, 1920-25) Prof. of Steam Power Engrg., Head of Mech. Engrg. Dept., Operating Consultant on Central Heating Plant and Underground Distribution System, • College of Engineering, University of Kentucky, Lexington, and 303 W. Oak St., Nicholasville, Ky.
- WESTENDARF, Francisco G.** (M 1939) Mgr., Carrier Dept., Guinand Freres Sucrs. Dept., Tecnico Apartado 668, Caracas, Venezuela.
- WESTOVER, Wendell** (M 1936) Pres., • Westover-Wolfe, Inc., 170 Washington Ave., and 254 Lenox Ave., Albany, N. Y.
- WESTPHAL, N. E.** (J 1940; S 1937) Ensign, U. S. N. R., • "B" Division Officer, U. S. S. Helena, c/o Postmaster, San Pedro, Calif., and Long Beach, Michigan City, Ind.
- WETHERED, Woodworth** (M 1938) The Bohemian Club, San Francisco, Calif.
- WETZEL, Horace E.** (M 1934) Vice-Pres. and Chief Engr., • The Smith & Oby Co., 6107 Carnegie Ave., Cleveland, and 21144 Aberdeen Rd., Rocky River, Ohio.
- WHEELER, Charles A.** (M 1941) Branch Mgr., • Johnson Service Co., 511 Fifth Ave., and 345 49th St. Pl., Des Moines, Iowa.
- WHEELER, Charles W.** (M 1916) Engr., • The Ric-wil Co., 1562 Union Commerce Bldg., Cleveland, and 11859 Edgewater Dr., Lakewood, Ohio.
- WHEELER, Joe, Jr.** (M 1938) Sales Repr., • Johnson Service Co., 28 East 29th St., New York, and 261 Dogwood Lane, Manhasset, L. I., N. Y.
- WHELAN, William J.** (M 1923) Estimating, • Harrigan & Reid Co., 1365 Bagley Ave., and 3790 Seminole Ave., Detroit, Mich.
- WHELLER, Harry S.** (M 1916) Vice-Pres., • L. J. Wing Manufacturing Co., 154 West 14th St., New York, N. Y., and 725 Union Ave., Elizabeth, N. J.
- WHITE, Eugene B.** (M 1934) Exec. Secy., • Architectural & Engineering Bureau, Young Men's Christian Assn., 19 S. LaSalle St., Chicago, and 126 S. East Ave., Oak Park, Ill.
- WHITE, Harry S.** (A 1936) Mgr., • Acme Sheet Metal Co., 5301 E. Ninth, and 6805 Edgevale Rd., Kansas City, Mo.
- WHITE, John C.** (M 1932) State Power Plant Engr., • State Bureau of Engineering, 624 E. Main St., and 622 E. Main St., Madison, Wis.
- WHITE, Thomas J.** (A 1941; J 1938) Sales Engr., • American Blower Corp., 625 Market St., San Francisco, and 2340 Pelham Pl., Piedmont Pines, Oakland, Calif.
- WHITE, W. Emery** (M 1941) Partner, • The Smith-White Co., 1102 Commerce Trust Bldg., and 7411 Ward Pkwy., Kansas City, Mo.
- WHITE, W. R.** (M 1938; A 1936) Industrial Engr., • Nebraska Power Co., 718 Electric Bldg., and 4916 Grand Ave., Omaha, Nebr.
- WHITEHURST, Bert W.** (M 1942) Stone & Webster Engineering Co., 49 Federal St., Boston, Mass.
- WHITELAW, H. Leigh** (M 1916) Jones & Laughlin Steel Corp., Third and Ross, and • 166 Ditheridge St., Pittsburgh, Pa.
- WHITMER, Robert P.** (M 1935) Secy., • American Foundry & Furnace Co., and 1402 E. Washington St., Bloomington, Ill.
- WHITNEY, C. W.** (M 1935) Pres., • ABC Oil Burner & Engineering Co., 2012-14 Chestnut St., Philadelphia, and Sevilla Court, Apt. F-3, Bala-Cynwyd, Pa.
- WHITT, Sidney A.** (A 1938; J 1937) Chief Design Engr., Fedders Manufacturing Co., Inc., 57 Tonawanda St., and • 12 Inwood Pl., Buffalo, N. Y.
- WHITTAKER, Wayne K.** (A 1935) Engr., Irving Trust Co. Bldg., 1 Wall St., New York, and • 119-23-226th St., St. Albans, L. I., N. Y.
- WHITTEN, H. E.** (M 1924) Pres.-Treas., H. E. Whitten Co., 9 Federal Court, Boston, and • 56 Highland Rd., Somerville, Mass.
- WHITTLESEY, Welsh C.** (M 1941) Engr. (Naval Archt.), Navy Dept., Washington, D. C., and • 1500 S. Barton St., No. 590, Arlington, Va.
- WIDDOWFIELD, A. S.** (A 1941; J 1937) Sales Engr., The Mercoid Corp., 4201 Belmont Ave., Chicago, Ill., and • 535 Hanna St., Birmingham, Mich.
- WIDMER, Walter J.** (A 1939) Secy.-Treas., • Widmer Plumbing & Heating Co. Inc., 34 N.E. Seventh Ave., and 1565 N. Shaver St., Portland, Ore.
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- WIEGNER, Henry B.** (M 1919) Office Mgr., Johnson Service Co., 20 Winchester St., Boston, and • 143 Standish Rd., Watertown, Mass.
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- WILHELM, Joseph E.** (A 1943; J 1936; S 1934) Chief Engr., Avery Engineering Co., 1906 Euclid Ave., Cleveland, and •294 East 195th St., Euclid, Ohio.
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- WILKINSON, Arthur** (A 1936) Flight Lt., Royal Canadian Air Force Hq., D. G. (P. S. O.), Lisgar Bldg., Ottawa, Ont., Canada.
- WILKINSON, F. J.** (M 1933) Mgr., Central Engrg. Service, Montgomery Ward & Co., Chicago Ave. and Larabee St., Chicago, and •78257 Martin Ave., Homewood, Ill.
- WILLARD, Arthur C.*** (M 1914) (*Presidential Member*) (Pres., 1928; 1st Vice-Pres., 1927; 2nd Vice-Pres., 1926; Council, 1925-29) Pres., •University of Illinois, 355 Administration Bldg., and 711 Florida Ave., Urbana, Ill.
- WILEY, Earl C.** (M 1934) Asst. Prof. of Mech. Engrg., Oregon State College, and •121 North 29th St., Corvallis, Ore.
- WILLIAMS, Allen W.** (*Life Member*; A 1915) Secy.-Treas., •National Warm Air Register Manufacturers Institute, Room 808, 5 E. Long St., Columbus, and 61 Meadow Park, Bexley, Ohio.
- WILLIAMS, Chester D.** (M 1938) Mgr., •General Air Conditioning & Heating Co., 3959 Piedmont Ave., Oakland, and 2709 College Ave., Berkeley, Calif.
- WILLIAMS, Donald D.** (M 1942; A 1940; J 1938) Htg. Engr., •Iowa-Nebraska Light & Power Co., 12th and N Sts., and 2236 A St., Lincoln, Nebr.
- WILLIAMS, Donald L.** (M 1941) Engr., •General Air Conditioning & Heating Co., 3959 Piedmont Ave., and 67 Glen Ave., Oakland, Calif.
- WILLIAMS, Elwin C.** (A 1939) Sales Repr., 4028 Egbert Ave., Cincinnati, Ohio.
- WILLIAMS, Frank H.** (A 1940; J 1934) War Staff (Mat'l. Procurement), General Motors Corp., Transportation Bldg., and •5009 Baltimore Ave. N.W., Washington, D. C.
- WILLIAMS, Gordon S.** (A 1941; J 1937; S 1936) Partner, Augur-Williams Co., 15 Chapel St., Woodmont, Conn.
- WILLIAMS, H. Edmund** (J 1939) Civilian Engr., Bureau of Yards and Docks, U. S. Navy Dept., 521 Fifth Ave., and •14 West 103rd St., New York, N. Y.
- WILLIAMS, J. Walter** (*Life Member*; M 1915) Pres.-Treas., •Forest City Plumbing Co., 332 E. State St., and 923 E. State St., Ithaca, N. Y.
- WILLIAMS, Lyle G.** (M 1939) Plbg. and Htg., •Crane Co., 419 Second Ave. S., and 5555-33rd Ave. N.E., Seattle, Wash.
- WILLIAMSON, Chester C.** (M 1942) Engrg. Dept., H. J. Heinz Co., 1062 Progress St., and •373 S. Pacific Ave., Pittsburgh, Pa.
- WILLNER, Ira** (M 1937) Pres., •Willner Heating Co., Inc., 415 Lexington Ave., and 125 East 93rd St., New York, N. Y.
- WILLS, Fred W.** (J 1938) Aviation Cadet, 5th Army Air Force Flying Training Detachment, Ryan Field, Sq. II, Cabin 43B, Hemet, Calif., and •2257 W. Addison St., Chicago, Ill.
- WILLSON, Frank J.** (M 1941) Vice-Pres., •Staynew Filter Corp., 11 Centre Park, and 2219 Westfall Rd., Rochester, N. Y.
- WILMOT, Charles S.** (M 1919) 436 Haverford Ave., Narberth, Pa.
- WILSON, Alexander M.** (J 1942; S 1939) Engr., Andrew Wilson Co., 616 Essex St., Lawrence, and •13 Third St., North Andover, Mass.
- WILSON, George T.** (M 1925) Sales Engr., Gurney Foundry Co., Ltd., 4 Junction Rd., Toronto, and •25 Tyre Ave., Islington, Ont., Canada.
- WILSON, James** (M 1942) Service Engr., Darling Bros. Ltd., 140 Prince St., Montreal, and •4259 Hingston Ave., N. D. G., Montreal, Que., Canada.
- WILSON, Raymond W.** (M 1934) Member of Firm, Wilson-Brinker Co., 309 Pythian Bldg., and •429 Creston Ave., Kalamazoo, Mich.
- WILSON, Robert A.** (M 1936) Sales Engr., Minneapolis-Honeywell Regulator Co., 5005 Euclid Ave., Cleveland, and •Briar Hill, Solon, Ohio.
- WILSON, Victor H.** (A 1938) Engr.-Distributor and Contractor in Refractories, Plibrico Jointless Firebrick Co., 403 Hitchcock Bldg., Nashville, and •"The Thistle-Patch," Donelson, Tenn.
- WILSON, Westray E.** (A 1939) Lt.-Col., Infantry, U. S. Army, Camp Murphy, Fla.; •Wilson Plumbing Co., 227 Haywood Rd., and 110 Salola St., Asheville, N. C.
- WILSON, W. H.** (A 1932) Chief Power Plant Engr., Pullman-Standard Car Manufacturing Co., 11001 Cottage Grove Ave., and •22 West 110th Pl., Chicago, Ill.
- WILTBERGER, Constant F.** (M 1935) Partner, Consulting Engrg., Pennell & Wiltberger, Land Title Bldg., and •2650 N. Ninth St., Philadelphia, Pa.
- WINANS, G. D.** (M 1929) Engr. of Steam Distribution, •The Detroit Edison Co., 2000 Second Ave., and 16183 Wisconsin, Detroit, Mich.
- WINKLER, Ralph A.** (A 1940; J 1937) Sales Engr., Alfred C. Goethel Co., 2337 North 31st St., Milwaukee, and •P. O. Box 179, Elm Grove, Wis.
- WINSLOW, C.-E. A.*** (M 1932) (Council, 1940-42) Prof. of Public Health, Yale University School of Medicine, and Dir., •John B. Pierce Laboratory of Hygiene, 310 Cedar St., and 314 Prospect St., New Haven, Conn.
- WINTERBOTTOM, Ralph F.** (M 1923) Engr., Winterbottom Supply Co., and •720 Moir, Waterloo, Iowa.
- WINTERER, Frank C.** (M 1920) Branch Sales Mgr., •American Radiator & Standard Sanitary Corp., 300 Broadway, and 836 Juno St., St. Paul, Minn.
- WISE, Mason W.** (M 1923) Owner, M. W. Wise Co., "Lakewood," and •1656 Melrose Dr. S.W., Atlanta, Ga.
- WISER, C. E.** (A 1941) Dist. Mgr., •Minneapolis-Honeywell Regulator Co., 3023 Farnam St., and 6312 Florence Blvd., Omaha, Nebr.
- WITHERIDGE, David E.** (J 1936) Consulting Engr., W. A. Witheridge Co., 2340 Mershon St., Saginaw, Mich.
- WITMER, Howard S.** (A 1937) Engrg. Dept., United States Rubber Co., 6600 E. Jefferson Ave., and •2217 Harding, Detroit, Mich.
- WITTIG, Frederick E.** (J 1939) Instructor, •Pratt Institute, 215 Ryerson St., Brooklyn, and Box 145, Glenwood Landing, N. Y.
- WOESE, Carl F.** (M 1934) Consulting Engr., •Robson & Woese, Inc., 1001 Burnet Ave., and 256 Robineau Rd., Syracuse, N. Y.
- WOLFE, John S.** (M 1941) Mech. Engr., Board of School Directors, 1012 W. Highland Ave., and •2004 N. Bartlett Ave., Milwaukee, Wis.
- WOLFF, Peter P.** (M 1935) Engr., Bell & Gossett Co., 3000 Wallace St., and •7333 Blackstone Ave., Chicago, Ill.
- WOLIN, Milton W.** (J 1938; S 1937) War Dept., and •R. F. D. 2, Box 73-D, New Brunswick, N. J.
- WOLL, Willard M.** (M 1938) Engr., Industrial Htg. and Refrig., •Commonwealth Edison Co., 72 W. Adams St., and 9320 S. Throop St., Chicago, Ill.
- WOLLENBERGER, Louis** (M 1938) Industrial Gas Engr., •Coast Counties Gas & Electric Co., 22 Pacific Ave., and 122 Davis St., Santa Cruz, Calif.
- WONG, Wilfred S. B.** (M 1938) Address Unknown—Mail Returned.
- WONSON, Arthur S., Jr.** (J 1941; S 1938) Navy Yard, Boston, and •Walnut Park Ave., Essex, Mass.

- WOOD, Alfred W.** (A 1941; J 1938) Royal Canadian Air Force, and •451 Margaret St., Preston, Ont., Canada.
- WOOD, Charles F.** (M 1937) Air Cond. Mgr., Prod. Development and Application Dept., Frigidaire Div., General Motors Sales Corp., 300 Taylor St., Dayton, and •R. R. 1, Spring Valley, Ohio.
- WOODGER, Herbert W.** (M 1939) Htg. and Vtg. Engr., •General Electric Co., 100 Woodlawn Ave., Pittsfield, and "Pineacres," East St., Lenox, Mass.
- WOODHOUSE, Graham D.** (A 1938) General Supt., Dowagiac Steel Furnace Co., and •304 West St., Dowagiac, Mich.
- WOODMAN, Lawrence E.** (M 1934) Pres., •Woodman Engineering Co., 203 E. Capitol, and 925 Adams, Jefferson City, Mo.
- WOODS, Baldwin M.** (M 1937) (Council, 1942) Dir. University Extension, Prof. Mech. Engrg., •University of California, 301 California Hall, and 249 The Uplands, Berkeley, Calif.
- WOODS, Charles F.** (A 1940) Town Plant Mgr., •Texas Southwestern Gas Co., and S. Baylor St., Brenham, Texas.
- WOODS, Edward H.** (M 1934) 916 College Ave., Niagara Falls, N. Y.
- WOOLLARD, Mason S.** (M 1934) Htg. Engr., Harry H. Angus Consulting Engr., 1221 Bay St., and •31 Hillcrest Park Ave., Toronto 5, Ont., Canada.
- WOOLCOCK, Edwin** (A 1938) Mgr., •Woolcock Plumbing & Heating Co., 2217-15th St., and 440 Memorial Pkwy., Niagara Falls, N. Y.
- WOOLSTON, A. H.** (M 1919) Chief Engr., •Woolston-Woods Co., 2132 Cherry St., and 4815 North 12th St., Philadelphia, Pa.
- WOOLSTON, Robert H.** (J 1941) Engr., •Woolston-Woods Co., 2132 Cherry St., and 358 W. Mt. Airy Ave., Philadelphia, Pa.
- WOOTEN, M. Frank, Jr.** (M 1941; A 1940) Consulting Engr., 104 Latta Arcade, and •400 Cherokee Rd., Charlotte, N. C.
- WORKMAN, Albert E.** (A 1941) Lt. (jg), U. S. N. R., and •14601 Bayes Ave., Lakewood, Ohio.
- WORMLEY, Robert F.** (A 1938) Branch Mgr., •Grinnell Company of Canada, Ltd., 700 Beaumont St., and 6092 Terrebonne Ave., Montreal, Que., Canada.
- WORSHAM, Herman** (M 1925; J 1918) Instructor at Ordnance Gun School, •Frigidaire Div., General Motors Corp., 300 Taylor St., and 524 Daytona Pkwy., Dayton, Ohio.
- WORTHINGTON, Thomas H.** (M 1937) Mgr., Eastern Htg. Sales, Standard Sanitary & Dominion Radiator, Ltd., 405 Beaubien St. W., Montreal, Que., Canada.
- WORTON, William** (M 1937) Branch Mgr., •C. A. Dunham Co., Ltd., 504 Scott Bldg., and 292 Lansdowne Ave., Winnipeg, Man., Canada.
- WRIGHT, Clarence E.** (A 1940; J 1935; S 1933) Mgr., Htg. and Vtg. Dept., Fairmont Wall Plaster Co., Tenth St., and •303 Nuzum Pl., Fairmont, W. Va.
- WRIGHT, Harris H.** (M 1917) Owner, •H. H. Wright Co., 1322 Walnut St., and 808 Greenway Terrace, Kansas City, Mo.
- WRIGHT, John B.** (M 1940) Sales Engr., •Nash Engineering Co., South Norwalk, and Rowayton, Conn.
- WRIGHT, K. A.** (M 1921) Branch Mgr., •Johnson Service Co., 1905 Dunlap St., Cincinnati, Ohio, and 113 Orchard Rd., Ft. Mitchell, Ky.
- WRIGHT, Norman S., Jr.** (A 1942; J 1941) Mfrs. Repr., •250 Perry St., San Francisco, and 22 Hillcrest Rd., Mill Valley, Calif.
- WRIGHTSON, Wilbur T.** (M 1937) Eastern Mgr., •Garden City Fan Co., 55 West 42nd St., New York, and 22 Sagamore Rd., Bronxville, N. Y.
- WUNDERLICH, Milton S.*** (M 1925) Gen. Sales Mgr., Insultite Div., Minnesota & Ontario Paper Co., 500 Baker Arcade, Minneapolis, and •545 Mt. Curve Blvd., St. Paul, Minn.
- WYATT, DeWitt H.** (M 1936) Mech. Engr., West Virginia Ordnance Works, Point Pleasant, W. Va., and •123 Acton Rd., Columbus, Ohio.
- WYLD, Reginald G.** (M 1937) Lt., U. S. N. R., Navy Dept., Office of Inspector of Naval Material, Pittsburgh Dist., and •407 Terminal Bldg., 65 Broad St., Rochester, N. Y.
- WYLLIE, Howard M.** (M 1925; J 1917) Vice-Pres. in charge of Sales, The Nash Engineering Co., and •51 Elmwood Ave., South Norwalk, Conn.

Y

- YAGER, John J.** (M 1921) Pres., Goergen-Mackwirth Co., Inc., 817 Sycamore St., and •425 Woodbridge Ave., Buffalo, N. Y.
- YAGLOU, Constantin P.*** (M 1923) Assoc. Prof. Industrial Hygiene, •Harvard School of Public Health, 55 Shattuck St., Boston, and 10 Vernon Rd., Belmont, Mass.
- YARBOROUGH, T. R.** (M 1938) Production and Inventory Analyst, W. P. B., Phoenix Bldg., Birmingham, Ala., and •1266 Stillwood Dr. N.E., Atlanta, Ga.
- YATES, Joseph E.** (M 1939) Asst. Engr., •Pacific Power & Light Co., 405 Public Service Bldg., and 1820 Northeast 57th Ave., Portland, Ore.
- YATES, Walter** (Life Member; M 1902) Governing Dir., •Matthews & Yates, Ltd., Cyclone Works, Swinton, and 4 Egerton Park, Worsley, Manchester, England.
- YERKES, William L.** (M 1941; A 1937) Engr., •Carrier Corp., S. Geddes St., Syracuse, N. Y., and •Box 153, Ithaca, Pa.
- YOUNG, Emil O.** (A 1935) Owner, •Young Regulator Co., 4500 Euclid Ave., Cleveland, and 3628 Cummins Rd., Cleveland Heights, Ohio.
- YOUNG, Harold J.** (M 1937) Sales Engr., Young Radiator Co., Occidental Hotel Bldg., and •1364 Lakeshore Dr., Muskegon, Mich.
- YOUNG, J. T., Jr.** (A 1936) Mgr., •Crane Co., Box 709, 20th and Wall, and 508 Ogden Canyon, Ogden, Utah.
- YOUNGER, John R.** (J 1941) U. S. N. R., Sp.3/c (T), U. S. Naval Training School, Wahpeton, N. D.

Z

- ZACK, H. J.** (M 1928) Prop., The Zack Co., 2311 Van Buren St., Chicago, Ill.
- ZAKI, Hussein M.** (J 1941; S 1940) Architectural Engr., 17 Cleopatra St., Heliopolis, Cairo, Egypt.
- ZEIGLER, Donald D.** (S 1942) Student, Carnegie Institute of Technology, Pittsburgh, Pa., and •243 N. St. Clair St., Dayton, Ohio.
- ZIBOLD, Carl E.** (M 1929) Mech. Engr., Htg. and Vtg., 13 Chadwick Rd., Westminster Ridge, White Plains, N. Y.
- ZIEBER, W. E.** (M 1935) Dir. of Research, •York Ice Machinery Corp., and 22 S. Keesey St., York, Pa.
- ZIEL, Herbert E.** (M 1924) Mech. Engr., •Albert Kahn, Associated Architects and Engrs., 345 New Center Bldg., and 694 Glynn Court, Detroit, Mich.
- ZIESSE, Karl L.** (A 1931) Partner, •Phoenix Sprinkler & Heating Co., 115 Campau Ave. N.W., and 315 Hampton Ave. S.E., Grand Rapids, Mich.
- ZINK, David D.** (M 1931) Lt.-Col., G. S. C., U. S. Army, Hq. I Armored Corps, A. P. O. No. 758, c/o Postmaster, N. Y., and •642 Lincoln St., Eugene, Ore.
- ZINTEL, George V.** (A 1941) Sales Engr., Himeibau Byfield & Co., 36 S. Throop St., and •1428 Summerdale, Chicago, Ill.
- ZUBER, Otto C.** (A 1938) Chief Engr., •Amana Society, Amana, and South Amana, Iowa.
- ZUMWALT, Ross** (A 1941; J 1938) Partner, •Zumwalt & Vinther, 707 Thomas Bldg., and 9435 Waterview, Dallas, Texas.
- ZUROW, William Allan** (J 1937) Ensign, U. S. N., and •728 S. Tenth St., St. Joseph, Mo.
- ZYNDA, John R.** (J 1942) Mech. Engr., Tool and Fixture Designer, Reliant Industries, Fisher Bldg., and •8876 Burt Rd., Detroit, Mich.

SUMMARY OF MEMBERSHIP

Presidential Members.....	23	Junior Members.....	263
Life Members.....	81	Student Members.....	27
Members.....	1675		
Associate Members.....	937	Total.....	3006

UNITED STATES

Alabama.....	8	Tennessee.....	17
Arizona.....	3	Texas.....	86
Arkansas.....	6	Utah.....	8
California.....	129	Vermont.....	3
Colorado.....	8	Virginia.....	55
Connecticut.....	40	Washington.....	49
Delaware.....	10	West Virginia.....	8
District of Columbia.....	88	Wisconsin.....	88
Florida.....	16	Wyoming.....	2
Georgia.....	57		
Idaho.....	1		2698
Illinois.....	249	DOMINION OF CANADA.....	218
Indiana.....	38		
Iowa.....	39	FOREIGN COUNTRIES	
Kansas.....	15	Australia.....	8
Kentucky.....	12	Bermuda Islands.....	1
Louisiana.....	36	Brazil.....	3
Maine.....	4	Chile.....	1
Maryland.....	58	Cuba.....	1
Massachusetts.....	100	Egypt.....	3
Michigan.....	182	England.....	35
Minnesota.....	93	India.....	4
Mississippi.....	4	Ireland.....	2
Missouri.....	110	Mexico.....	3
Montana.....	3	New Zealand.....	3
Nebraska.....	21	Puerto Rico.....	3
Nevada.....	5	South Africa.....	5
New Jersey.....	112	Sweden.....	6
New York.....	380	Turkey.....	1
North Carolina.....	43	Venezuela.....	2
Ohio.....	185		
Oklahoma.....	15		81
Oregon.....	43	Addresses Unknown.....	9
Pennsylvania.....	248	TOTAL MEMBERSHIP.....	3006
Rhode Island.....	7		
South Carolina.....	12		
South Dakota.....	2		

LIST OF MEMBERS

(Geographically Arranged)

UNITED STATES *and* POSSESSIONS

ALABAMA

Attalla—

Gilliland, L.

Birmingham—

Gause, H. C.
Myer, H.
Richards, G. H.
Walden, H. K.

Montgomery—

Dowdy, R. B.
Drum, L. J., Jr.

Tuscaloosa—

Murphree, R. L.

ARIZONA

Phoenix—

Chapman, W. A., Jr.
Hummell, G. W.

Tucson—

Tidmarsh, P. M.

ARKANSAS

Fort Smith—

Schuster, P. H.

Little Rock—

Cumnock, H.
McCoy, C. E.

Pine Bluff—

Carnahan, J. H.
Hellmers, C. C., Jr.

Texarkana—

Kribs, C. L., Jr.

CALIFORNIA

Bakersfield—

Baker, H. S.

Berkeley—

Atkins, G. E.
Baldwin, K. F., Jr.
Fluckey, K. N.
Hutchinson, F. W.
Murphy, E. F.
Peterson, C. L.
Porter, N. E.
Raber, B. F.
Woods, B. M.

Beverly Hills—

Theobald, A.

Burlingame—

Hill, J. A.

Camp Roberts—

Green, E. W.

El Monte—

Hazlehurst, H. D.

Fresno—

Newman, H. E.

Glendale—

Eggleston, H. L.
Schofield, P. C.
Storms, R. M.
Wells, E. P.

Huntington Park—

Bullock, H. H.
Stanley, R. L.

Long Beach—

Barth, J. W.
Billingsley, O. F. H., II

Los Angeles—

Anderson, C. S.
Cummings, T. P.
DeFlon, J. G.
deMena, L. I.
Dieter, G. H.
Dullender, E. A.
Downes, A. H.
English, H.
Fabling, W. D.
Fulmor, I. P.
Gunzel, R. M.
Hendrickson, H. M.
Hess, A. J.
Hokanson, C. G.
Hungerford, L.
Kennedy, M.
Kilpatrick W. S.
Lauer, H. B.
Lowe, R. A.
McKenzie, M. C., Jr.
Moriarty, J. M.
Ness, W. H. C.
Orcar, A. G.
Ott, O. W.
Park, J. F.
Parks, C. E.
Parsons, J. H.
Phillips, R. E.
Phillips, R. H.
Rodeffer, E. W.
Stewart, W. O.
Walker, W. F.
Webber, C. H.

March Field—

Owen, J. D.

Mill Valley—

Vinson, N. L.

Oakland—

Babcock, P. R.
Blumenthal, M. I.
Cummings, G. J.
Emanuels, M.
Kurtz, O.
Murphy, D. I.
Shepard, C. R.
Terry, S. W.
Williams, C. D.
Williams, D. L.

Pacific Palisades—

Finney, B.

Palo Alto—

Johnson, O. W.

Pasadena—

Gifford, R. L.

Paso Robles—

Hill, E., Jr.

Redwood City—

Hudson, R. A.

Salinas—

Towle, P. H.

San Diego—

Elizabeth, R.
Keeter, D. M.
Sadler, C. B.

San Francisco—

Akers, G. W.
Bentley, C. E.
Bouey, A. J.
Brown, S. D.
Cochran, L. H.
Cooley, E. C.
Cushing, R. C.
Folsom, R. A.
Fanning, E. C.
Gayner, J.
Goins, E. H.
Haley, H. S.
Herre, H. A.
Hickman, H. V.
Holland, R. B.
Hook, F. W.
Howes, E. W.
Hunter, T. B.
Kaup, E. O.
Kolb, F. W.
Kooistra, J. F.
Krueger, J. I.
Leland, W. E.
Martin, G. D.
McIndoe, J. F.

Melnick, N. A.
Molino, P.
Parker, R. A.
Peterson, N. H.
Ploskey, E. J.
Reed, V. C.
Reilly, P. H., Jr.
Rosen, E. J.
Scandrett, H. R.
Schlick, P. F.
Scott, R. M.
Scott, W. P., Jr.
Simons, E. W.
Simonson, G. M.
Sprott, J. I.
Wayland, C. E.
Wethered, W.
White, T. J.
Wright, N. S., Jr.

San Gabriel—

Griffith, J. B.

San Marino—

McGowan, T. E.

San Pedro —

Westphal, N. E.

Santa Cruz —

Wollenberger, L.

Santa Monica—

Coghlan, S. F.

Piedmont—

Martin, J. O.

South Pasadena—

Jones, D. R. A.

Victorville—

Bachofer, H. A., Jr.

COLORADO

Colorado Springs —

Jardine, D. C.

Denver—

Adams, F. L.
Maves, G. D.
McNevin, J. E.
McQuaid, D. J.
O'Rear, L. R.

La Junta—

Curtice, J. M.

Pando—

Selig, E. T., Jr.

ROLL OF MEMBERSHIP

CONNECTICUT

Bridgeport—
Clement, E. R., Sr.
Earle, F. E.
Palumbo, B. F.

Danbury—
Moore, M.

Elmwood—
Fischer, L. W.

Fairfield—
Osborn, W. J.
Smak, J. R.

Greenwich—
Jones, A. L.

Hamden—
Secley, L. E.

Hartford—
Bemis, P. D.
Peterson, H. P.

Manchester—
Leitgabel, K. A.

New Britain—
Hart, S.
Hart, T. S.

New Haven—
Blakeley, H. J.
Converse, T. J.
Roeder, W.
Teasdale, L. A.
Winslow, C.-E. A.

New London—
Chapin, C. G.
Forsberg, W.
Hopson, W. T.

Old Greenwich—
Ingham, J. F.

Riverside—
Murphy, J. R.

South Norwalk—
Adams, H. E.
Jennings, I. C.
Lyons, C. J.
Mead, F. A.
Wright, J. B.
Wylie, H. M.

Stamford—
Jessup, B. H.

Torrington—
Doster, A.
Upson, W. L.

Waterbury—
Osborne, S. R.
Simpson, R. L.
Simpson, W. K.
Stein, J.

West Hartford—
Hoyt, L. W.

Westport—
Faile, E. H.

Woodmont—
Williams, G. S.

DELAWARE

Claymont—
Ginzburg, N.

Milford—
Downing, C. B.

Wilmington—
Burke, J. J.
Granke, A. A.
Hayman, A. E., Jr.
Kershaw, M. G.
Lownsbey, B. F.
Farvis, R. S.
Robinson, G. L.
Schoenijahn, R. P.

DISTRICT OF COLUMBIA

Friendship Station—
Burns, H. J.

Washington—
Bichowsky, F. R.
Bornstein, A. B.
Bornstein, W.
Brown, L. S., Jr.
Brunner, E. G.
Campbell, G. W.
Carson, C. C.
Clo, H. E.
Crawford, A. C.
Cullen, A. G.
Day, I. M.
Devore, A. B.
Dovener, R. F.
Downes, H. H.
Ellis, G. P.
Erismann, P. H., Jr.
Espenschied, F. F.
Faxon, H. C.
Febrey, E. J.
Feltwell, R. H.
Frankel, G. S.
Graves, V.
Hall, M. S.
Hanlein, J. H.
Hannigan, W.
Heagerty, W. H.
Hertzler, J. R.
Hill, H. H.
Hill, W. W.
Holder, L. H.
Holmes, P. B.
Hoppe, M. F.
Houghten, F. C.
Inman, C. M.
Iverson, H. R.
Jones, W. C.
Kizales, M. D.
Kidd, C. R.
Kingswell, W. E.
Kugel, H. K.
Latterner, H., Jr.
Lauer, R. F.
Leser, K. A.
Lewis, T.
Littleford, W. H.
Lloyd, E. H.
Loughran, P. H., Jr.
Maurer, L.
McCormick, G. W., Jr.
McCusker, J. P.
McEntee, F. M.
McKay, A. W.
McLouth, B. F.
Meinholtz, H. W.

Mergardt, A. P.
Miller, G. F.
Millham, F. B.
Mitchell, A. E.
Nelson, H. M.
Nolan, J. J., Jr.
Norair, H.
Ourusoff, L.
Peacock, H.
Phillips, W. L.
Robinson, D. M.
Roper, R. F.
Ryerson, H. E.
Sale, F. B.
Schulze, B. H.
Shapiro, M.
Shire, A. C.
Small, R. A.
Steel, R. J.
Sterne, C. M.
Stewart, J. N.
Stock, C. S.
Sutter, E. E.
Terry, M. C.
Thomas, G.
Thompson, N. S.
Tuxhorn, D. B.
Urdahl, T. H.
Van Alsburg, J. H.
Vaughan, J. G., Jr.
Walford, L. C. A.
Werner, J. G.
Williams, F. H.

FLORIDA

Camp Murphy—
Diamond, D. D.

Holly Hill—
Odum, R. A.

Jacksonville—
Allen, W. W.
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Hutchinson, B. L., Jr.
Juergens, W. A.
Junker, W. H.
Killian, W. J.
Kinney, A. M.
Kramig, R. E., Jr.
Kuempel, L. L.
Leupold, G. L.
Mathewson, M. E.
McNamee, E. W.
Moore, H. W.
Motz, O. W.
Mursinna, G. P.
Neal, J. P.
Pfriem, P. G.
Pillen, H. A.
Pistler, W. C.
Richard, E. J.
Ruff, A. G.
Sigmund, R. W.
Silberstein, B. C.
Sproull, H. E.
Stevens, W. R.
Sutlin, G. V.
Thompson, E. B.
Ward, F. J.
Washington, L. W.
Williams, E. C.
Wright, K. A.

Cleveland—
Auer, G. G.
Baggaley, W.
Beach, W. R.
Berger, J. L.
Borkat, P.
Byers, R. L.
Cohen, P.
Conner, R. M.

Cummings, R. J.
Curtis, H. F.
Cushing, C. F.
Evans, W. A.
Eveleth, C. F.
Findley, H. N.
Fleming, P. B.
Friedman, A.
Gayman, P. D.
Geltz, R. W.
Gottwald, C.
Gray, E. W.
Hall, J. R.
Hall, N. H.
Harvey, L. C.
Heisterkamp, H. W.
James, J. W.
Jones, J. P.
Kaercher, C. M. H.
Kajuk, A. E.
Kitchen, F. A.
Klie, W.
LaSavia, J. J.
Lavelle, A. E.
Levy, M. I.
Machen, J. T.
McKeeman, C. A.
Miles, J. C.
Moore, W. R.
Nachman, G. P.
Nobis, H. M.
Pinney, T. M.
Platz, J. F.
Pogalica, L. H.
Powers, L. G.
Priester, G. B.
Reich, J. G.
Repp, H. L.
Rowe, W. M.
Slawson, L. E.
Stark, W. E.
Steffner, K. F.
Taze, D. L.
Terhune, R. D.
Tuve, G. L.
Vanderhoof, A. L.
Webb, E. C.
Weldy, L.
Wetzell, H. E.
Wheeler, C. W.
Young, E. O.

Cleveland Heights—
Cady, E. F.
Clark, R. L.
Cutting, R. H.
Dickens, L. A.
Mannen, D. E., Jr.
Rhoton, W. R.

Columbus—
Allonier, H. R.
Benson, M. L.
Breneman, R. B.
Brown, A. I.
Engdahl, R. B.
Myler, W. M., Jr.
Oelgoetz, J. F.
Sherman, R. A.
Slemmons, J. D.
Williams, A. W.
Wyatt, D. H.

Cortland—
Swenchart, D. W.

Covington—
Sandfort, J. F.

Cuyahoga Falls—
Humphrey, D. E.

Dayton

Anoff, S. M.
Baker, J. C.
Black, J. M.
Brown, J. S., Jr.
Brown, T.
Gibbons, M. J., Jr.
Gowdy, A. C.
Lindsay, G. W., Jr.
Smith, N. J.
Weaver, J. v. O.
Worsham, H.
Zeigler, D. D.

East Cleveland

Geiger, R. L.

Elyria

Ray, G. E.

Euclid

Reardon, J. F.
Wilhelm, J. E.

Glendale

Thomas, R. H.

Hamilton

Crane, R. S.
Thomas, L. G. L.

Kent

Sagnor, S. V.

Lakewood

Longcoy, G. B.
Schurman, J. A., Jr.

Lawton

McClung, T. H.

Lima

Hawisher, H. H.

Lorain

Jackson, W. F.

Marionmont

Cherne, R. E.
Murphy, C. G.

Marion

Holden, R. G.

Middletown

Byrd, T. I.
Somers, W. S.

Newark

Waggoner, J. H.

Oberlin

Ries, L. S.
Sable, E. J.

Painesville

Hobbs, J. C.

Piqua

Lange, R. T.

Shaker Heights

Avery, L. T.
Foley, J. L.

Solon

Wilson, R. A.

South Park

Barney, W. E.

Spring Valley

Wood, C. F.

Toledo

Jones, S.
Lewis, H. E.
Watkins, G. B.

Warren

Manning, C. E.

Waverly

Armbruster, F. T. W.

Wilmington

Marconett, V. G.
Sapp, C. L.

Youngstown

Montgomery, J. R.
Sgambati, A. P.
Stangle, W. H.

OKLAHOMA

Lawton

MacGregor, C. M.

McAlester

Green, S. H.

Norman

Dawson, E. F.

Oklahoma City

Beals, D. E.
Braniff, P. F.
Dolan, R. G.
Doughty, C. J.
Ellingson, E. T. P.
Gray, E. W.
Loeffler, F. X., Sr.
Melton, H. E.
Morin, A. R.

Tulsa

Dean, C. H.
Holmes, A. D.
Jones, E.

OREGON

Corvallis

Willey, E. C.

Eugene

Chase, P. S.
Zink, D. D.

Hermiston

Sutch, H. C.

Medford

Hoey, J. K.

Portland

Armstrong, C. E.
Banks, J. B.
Brissenden, C. W.
Burtchall, J. T.
Burton, W. R.
Byrne, J. J.
Campau, W. R.
Carroll, E. E.
Farnes, B. W.
Finlay, A. E.

- Finnigan, W. T.
Freeman, J. A.
Gehrs, W.
Goehler, E. E.
Gibbon, J. H.
Harrington, L. J.
Heinkel, C. E.
Johnston, A. K.
Kollas, W. J.
Kroeker, J. D.
Lynch, J. R.
McDermott, J. P.
Mead, H. K.
Moore, B. W.
Morrison, W. B.
Murhard, E. A.
Neubauer, E. W.
Nielsen, H. B.
Ponder, E. A.
Riley, J. N.
Risley, G. H.
Taylor, T. E.
Turner, E. S.
Urban, F. F.
Widmer, W. J.
Yates, J. E.
- Salem—**
Cooper, D. E.
VanWyngarden, J. E.
- PENNSYLVANIA**
- Abington—**
Park, N. W.
- Allentown—**
Goundie, J. K.
Hersh, F. C.
Hilder, F. L.
Korn, C. B.
- Ambler—**
McElgin, J. W.
- Ardmore—**
Haynes, C. V.
- Avondale—**
Battan, S. W.
- Ben Avon—**
McGonagle, A.
- Bethlehem—**
Curley, E. I.
Stuart, M. C.
- Brookline (Del. Co.)**
Eastman, C. B.
- Bryn Mawr—**
McIlvaine, J. H.
- Coudersport—**
Reese, H. L.
- Dravosburg—**
Marshall, A. W.
- Drexel Hill—**
Mather, H. H.
Matz, G. N.
- Dunbar—**
Sherwood, L. T.
- East Pittsburgh—**
Hazlett, T. L.
Penney, G. W.
- Elizabethtown—**
Dibble, S. E.
- Erie—**
Meyers, C. F.
Sullivan, T. J.
- Freeport—**
McCullough, J. L.
- Glenmoore—**
Gant, H. P.
- Glenside—**
Macfarlan, N. S.
Tucker, L. A.
- Harrisburg—**
Eicher, H. C.
Geiger, I. H.
- Haverford—**
Arnold, R. S.
- Hershey—**
Snively, A. B.
- Irwin—**
Cost, G. W.
- Ithaca—**
Crew, F. D.
Yerkes, W. L.
- Johnstown—**
Hunter, L. N.
Knowles, F. R.
- Kingston—**
MacDonald, D. B.
- Lancaster—**
Jones, A.
Lloyd, E. C.
Weitzel, P. H.
- Lansdowne—**
James, H. R.
Seltzer, P. A.
- Manheim—**
Weitzel, C. B.
- McKeesport—**
Dugan, T. M.
- Middletown—**
Locke, R. A.
- Milton—**
Mohn, H. L.
- Narberth—**
Grant, W. A.
Searle, W. J., Jr.
Smith, W. F.
Wilmot, C. S.
- New Hope—**
Davidson, P. L.
- New Kensington—**
Edwards, J. D.
Shearer, W. A., Jr.
- Oxford—**
Ware, J. H., III
- Philadelphia—**
Bachman, F.
Ballman, W. H.
Barnard, M. E.
Barr, G. W.
Bartlett, C. E.
Bates, J. H.
Belford, L. duB.
Black, E. N., III
Black, H. G.
Blankin, M. F.
Bogaty, H. S.
Bornemann, W. A.
Borton, A. R.
Buck, L.
Burritt, E. E., Jr.
Caldwell, A. C.
Call, J.
Childs, L. A.
Cody, H. C.
Culbert, W. P.
Dafer, E. H.
D'Ambly, A. E.
Davidson, L. C.
Dietz, C. F.
Dome, A. G.
Donovan, W. J.
Elliot, E.
Erickson, H. H.
Fallenbacher, H. J.
Farrington, S. E.
Goff, J. A.
Hedges, H. B.
Holland, G. R.
Hucker, J. H.
Hunger, R. F.
Hutchinson, J. E.
Ickeringill, J. G.
Jacobson, K. C. S.
Jakoby, A. C.
Kahn, C. R., Jr.
Keeling, F. V.
Kelble, F. R.
Kirkbride, J. O.
Kriebel, A. E.
Ladd, D.
Landau, M.
Lee, R. J.
Leonard, R. R.
Leopold, C. S.
Lyon, P. S.
Mack, L.
Macrow, L.
Makin, H. T., Jr.
Martocello, J. A.
McCullough, H. G.
Mellon, J. T. J.
Meloney, E. J.
Mensing, F. D.
Moody, L. E.
Morgan, R. C.
Murdoch, J. P.
Nesbitt, A. J.
Nusbaum, L.
Nusbaum, S. R.
Parent, H. M.
Peller, L.
Pfeiffer, F. F.
Plewe, S. E.
Powell, G. W., Jr.
Powers, Earle C.
Powers, Edgar C.
Prewitt, H. B.
Prybille, P. L.
Redstone, A. L.
Rettew, H. F.
Roberts, E. F., Jr.
Roberts, H. L.
Rugart, K.
Semel, E.
Sheffer, M.
- Shore, D.**
Smiles, R. H.
Smith, D. J.
Speckman, C. H.
Stewart, J. P.
Timmis, P.
Touton, R. D.
Traugott, M.
Tuckerman, G. E.
von Rosenberg, P. C.
Wagner, E. K.
Wegmann, A.
Wells, W. F.
Whitney, C. W.
Wiley, D. C.
Wiltberger, C. F.
Woolston, A. H.
Woolston, R. H.
- Pittsburgh —**
Allen, W. A.
Alvarez, J.
Baker, W. H., Jr.
Beatty, J. W.
Beighel, H. A.
Brauer, R.
Braun, C. R., Jr.
Breyer, F.
Bushnell, C. D.
Collins, J. F. S., Jr.
Comstock, G. M.
Cooperman, E.
Cox, S. F.
Daly, R. E.
Dickinson, R. P., Jr.
Dorfan, M. I.
Edwards, P. A.
Hach, E. C.
Hamilton, M. S.
Hebley, H. F.
Hecht, F. H.
Heilman, R. H.
Humphreys, C. M.
Hyde, E. H.
Jones, L. K.
Kirkendall, H.
Lifton, D.
Loucks, D. W.
Machling, I. S.
Mahon, F. B.
Maier, G. M.
McIntosh, F. C.
Metzger, A. F.
Miller, R. A.
Moore, H. L.
Mueller, J. E.
Nass, A. F.
Park, H. E.
Peacock, G. S.
Proie, J.
Reed, V. A., Jr.
Reed, W. H., III
Reilly, B. B.
Riesack, W. L.
Riesmeyer, E. H., Jr.
Rockwell, T. F.
Rose, H. J.
Ross, D. S.
Schneider, C. H.
Sheppard, W. K.
Simpson, G. L.
Small, B. R.
Smyers, E. C.
Speller, F. N.
Stanger, R. B.
Steggall, H. B.
Stevenson, W. W.
Sweeney, R. H.
Strauch, P. C.
Tennant, R. J. J.
Tower, E. S.
Waters, G. G.
Weddell, G. O.
Whitelaw, H. L.
Williamson, C. C.

ROLL OF MEMBERSHIP

Pottstown -
Harbinger, G. L.

Primos -
Johnson, A. J.
King, J. S.

Reading -
Luck, A. W.

Ridley Park -
Mawby, P.

Scranton -
Gilboy, J. P.
Mahon, B. B.

Sewickley -
Fullman, J. B.

Springdale -
Lynn, F. E.

Stroudsburg -
Kiefer, E. J.

Swarthmore -
Hobbs, W. S.
Robinson, A. S.
Thom, G. B.

Uniontown -
Marks, A. A.

Upper Darby--
Ahlf, A. A.
Bertrand, G. F.
Kipe, J. M.

Villanova -
Morehouse, J. S.

Washington --
Frazier, J. E.

Westtown -
Landfried, C. L.

Wilksburg --
Biber, H. A.
Campbell, T. F.
Good, C. S.
Hershey, A. E.

Williamsport--
Axeman, J. E.

York--
Bryan, W. L., Jr.
DuBois, L. J.
Mirabile, J. J.
Nicoll, S. F.
Walsh, E. R., Jr.
Zieber, W. E.

RHODE ISLAND
Greenwood--
Austin, W. H.

Newport -
Forbes, H. B., Jr.

Providence --
Blanding, R. L.
Coleman, J. B.
Easley, H. A.
Gibbs, E. W.
Hartwell, J. C.

SOUTH CAROLINA

Charleston -
Bailey, F. A., Jr.
Burns, F. G.
Herty, F. B.

Columbia --
Hartin, W. R., Jr.
Kerr, W. E.
McDowell, H. L.
Sherman, W. P.

Fort Jackson --
Rheault, W. E.
Sloane, D. J.

Greenville -
Ramseur, V. D., Jr.
Waldrep, J. E.

Myrtle Beach -
Laseter, F. L.

SOUTH DAKOTA

Lead
Pullen, R. R.

Sioux Falls -
Monick, F. R.

TENNESSEE

Bristol -
Torok, E.

Donelson --
Wilson, V. H.

Johnson City --
Lantz, F. A.

Kingsport--
Herbert, J. S.

Knoxville -
Cross, F. G.
Oakley, L. W.

Memphis --
Campbell, A. Q., Jr.
Danielson, W. A.
Hoshall, R. H.
Shelby, A. W.

Nashville--
Armistead, W. C.
Brown, F.
Campbell, G. S.
Campbell, R. P.
Fly, E. P.
Norte, W. R.

Smyrna --
Friedman, D. H., Jr.

TEXAS

Amarillo--
Burnett, E. S.

Beaumont --
Stiell, J.

Brenham --
Woods, C. F.

Bryan --
Stiles, G. S.

Camp Hood--
Badgett, W. H.

Camp Wallace--
Cox, V. G.

Camp Wolters--
Clow, S. A.

College Station--
Hopper, J. S.
Long, W. E.
Smith, E. G.

Corpus Christi--
Holsworth, R. C.

Dallas--
Allison, R. E.
Anspacher, T. H.
Bishop, J. A.
Blum, H., Jr.
Brown, M. L.
Brown, M. W.
Carroll, W. M.
Dowdell, J. R.
Farrow, E. E.
Gammill, O. E., Jr.
Gardner, C. R.
Gessell, E. T.
Gilbert, L. S.
Jelinek, F. R.
Lyford, R. G.
Marty, H. J.
McClanahan, L. C.
Moler, W. H.
Nation, O.
Newby, I. P.
Pines, S.
Pfeiffer, D. C.
Ray, J. A.
Rodgers, F. A.
Stern, E. J.
Townsend, J. M.
Warren, H. P.
Zumwalt, R.

Denison--
Linskie, G. A.

Ellington Field--
Boyd, R. L., Jr.

El Paso --
Light, J. C.

Fort Sam Houston--
Stern, D. S.

Fort Worth--
Edwards, C. E.
MacEachin, G. C.
Miller, B. R.
Skinner, H. W.
Werner, R. K.

Fremont--
Kurtz, R. W.

Galveston--
Disney, M. A.
Norris, W. P.

Goose Creek--
Rhine, G. R.

Houston--
Andrews, W. M.
Banowsky, A. B.
Barnes, A. F.
Bible, H. U.
Chase, A. M., Jr.
Cooper, D. S.
Howell, L.
Johnson, R. B.
McKinney, C. A.
Mills, D. M.
Mitchell, A. J.
Morrow, J. D.
Olson, G. E.
Owings, H. L.
Tanner, G. J.
Taylor, R. F.
Walsh, J. A.
Way, W. J., II.
Workman, A. E.

Lubbock--
Ainsworth, S. E.
Herbert, R. M.

San Antonio--
Barnes, R. W.
Diver, M. L.
Ebert, W. A.
Feldstein, H.
Pawckett, L. S.
Rummel, A. J.
Shafer, W. P., Jr.

Texarkana--
Knepper, H. H.
Perkins, R. C.

Waco--
Benham, F. C., Jr.
Gamble, C. B.

Weatherford--
Hughes, S.

Wichita Falls--
Pettit, E. N., Jr.

UTAH

Holliday--
Walz, C. D.

Layton--
Brokaw, G. K.
Rumsey, J. L.

Logan--
Wangsgaard, D.

Ogden--
Young, J. T., Jr.

Salt Lake City--
Cockins, W. W.
Jones, J. T.
Richardson, H. G.

VERMONT

Burlington--
Lanou, J. E.
Raine, J. J.

Woodstock--
Ambrose, A. H.

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VIRGINIA

Alexandria—

Ammerman, C. R.
Broderick, E. L.
Fogg, J. H.
Gault, G. W.
Goergens, A. G.
Norrlington, W. L.
Skagerberg, R.

Arlington—

Achenbach, P. R.
Bartels, E. M.
Cover, R. R.
Fife, G. D.
Grimes, F. M.
Hackett, F. C.
Horne, H. F.
Iverstrom, C.
Kolakoski, R.
Lively, G. P.
Marshall, W. D.
Martens, E. D.
Queer, E. R.
Roach, E. R.
Stokes, A.
Timmis, W. W.
Whittlesey, W. C.

Camp Lee—

Cropper, R. O.
McCain, H. K.

Danville—

Farley, W. S.

Falls Church—

Koster, H. H.
Ley, R. B.
Rogers, C. S.

Fort Belvoir—

Marshall, T. A.
Muirheid, J. G.

Fort Eustis—

Ibison, J. L.

Lawrenceville—

Jones, H. S.

Lynchburg—

Doering, F. L.

McLean—

Nye, L. B., Jr.

Norfolk—

Brewer, F. M.
Davidson, J. C.
Jalonack, I. G.
Lee, B. H.
Nowitzky, H. S.
Thomas, R. C.
Webster, W. H., Jr.

Portsmouth—

Bensinger, M.
Rosenberg, I.
Stubbs, W. C.

Richmond—

Bernert, L. A.
Carle, W. E.

Johnston, J. A.
Pebbles, J. K., Jr.
Schulz, H. I.
West, C. H., Jr.

Roanoke—

Bailey, A. E., Jr.

Williamsburg—

McGinnis, F. L.

Windsor—

Bailey, C. F.

WASHINGTON

Anacortes—

Hanthorn, W.

Bremerton—

Bysom, L. L.
Dominy, C. B.
Naman, I. A.
Smith, C. F., Jr.

Fort Lewis—

Pellmouther, T. V.
Sharp, J. R.

Kent—

Boyker, R. C.

Longview—

Pauley, R. D.

Parkland—

Norby, K. H.

Port Orchard—

Pratt, F. J.

Seattle—

Barnum, W. E., Jr.
Beggs, W. E.
Bouillon, L.
Clark, A. C.
Conrad, R.
Cox, W. W.
Eastwood, E. O.
Faulkner, J. H.
Grabman, H. B.
Granston, R. O.
Griffith, H. T.
Hauan, M. J.
Langdon, E. H.
Leichnitz, R. W.
LeRiche, R. E.
Mallis, W.
Marvin, J. H.
Matthies, L. A.
May, C. W.
Mead, G. E.
Morse, R. D.
Peterson, S. D.
Pollard, A. L.
Muggrave, M. N.
Sparks, J. D.
Twist, C. F.
Wallis, W. M.
Watt, R. D.
Weber, E. L.
Wesley, R. O.
Williams, L. G.

Spokane—

Chase, R. E., Jr.
Kelly, J. C.

Tacoma—

Chase, R. E.
Foote, E. E.
Spofforth, W.

Wenatchee—

Clausen, A. H.
Segle, T. L.

WEST VIRGINIA

Charleston—

Pugh, D. C.
Rosenblatt, A. M.
Shanklin, J. A.

Fairmont—

Tonry, R. C.
Wright, C. E.

Huntington—

Johnson, L.

Largent—

Donnelly, J. A.

Parkersburg—

Bartels, C. J.

WISCONSIN

Clintonville—

Quall, C. O.

Elm Grove—

Winkler, R. A.

Kohler—

Hvoslef, F. W.

LaCrosse—

Anderegg, R. H.
Goodman, W.
Rowe, W. A.
Trane, R. N.

Lake Delton—

Page, H. W.

Madison—

Dean, C. L.
Feirn, W. H.
Hall, G.
Klefoth, M. H.
Larson, G. H.
Nelson, D. W.
Seymour, J. E.
White, J. C.

Manitowoc—

Ellis, G. W.

Marshfield—

Himsel, S. R.

Milwaukee—

Alfery, H. F.
Allan, W.
Bishop, M. W.
Boden, W. F.
Bowers, A. F.
Brown, W. H.
Cutler, J. A.
Davis, D. W., Jr.
Davis, K. T.

Ellis, H. W.
Frentzel, H. C.
Gerstenberger, E. J.
Gifford, E. W.
Goldsmith, F. W.
Griewisch, A. H.
Haerle, R. A.
Hamacher, K. F.
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President.....Homer Addams
1st Vice-President.....S. E. Dibble
2nd Vice-President.....William H. Driscoll
Treasurer.....Perry West
Secretary.....F. C. Houghten

Council

Chairman, Homer Addams
S. E. Dibble, Vice-Chm. W. E. Gillham
F. Paul Anderson L. A. Harding
W. H. Carrier Alfred Kellogg
J. A. Cutler Thornton Lewis
William H. Driscoll Perry West
H. P. Gant F. C. Houghten, *Secy.*

1925

President.....S. E. Dibble
1st Vice-President.....Wm. H. Driscoll
2nd Vice-President.....F. Paul Anderson
Treasurer.....Perry West
Secretary.....F. C. Houghten

Council

Chairman, S. E. Dibble
Wm. H. Driscoll, Vice-Chm. W. T. Jones
Homer Addams Thornton Lewis
F. Paul Anderson J. H. Walker
W. H. Carrier Perry West
J. A. Cutler A. C. Willard
W. E. Gillham F. C. Houghten, *Secy.*

1926

President.....W. H. Driscoll
1st Vice-President.....F. Paul Anderson
2nd Vice-President.....A. C. Willard
Treasurer.....W. E. Gillham
Secretary.....A. V. Hutchinson

Council

Chairman, W. H. Driscoll
F. Paul Anderson, Vice-Chm. C. V. Haynes
W. H. Carrier W. T. Jones
J. A. Cutler E. B. Langenberg
S. E. Dibble Thornton Lewis
W. E. Gillham J. F. McIntire
A. C. Willard

1927

President.....F. Paul Anderson
1st Vice-President.....A. C. Willard
2nd Vice-President.....Thornton Lewis
Treasurer.....W. E. Gillham
Secretary.....A. V. Hutchinson

Council

Chairman, F. Paul Anderson
A. C. Willard, Vice-Chm. John Howatt
H. H. Angus W. T. Jones
W. H. Carrier J. J. Kissick
W. H. Driscoll E. B. Langenberg
Roswell Farnham Thornton Lewis
H. H. Fielding J. F. McIntire
W. E. Gillham H. Lee Moore
C. V. Haynes F. B. Rowley

1928

President.....A. C. Willard
1st Vice-President.....Thornton Lewis
2nd Vice-President.....L. A. Harding
Treasurer.....W. E. Gillham
Secretary.....A. V. Hutchinson

Council

Chairman, A. C. Willard
Thornton Lewis, Vice-Chm. C. V. Haynes
F. Paul Anderson John Howatt
H. H. Angus W. T. Jones
W. H. Carrier J. J. Kissick
N. W. Downes E. B. Langenberg
Roswell Farnham J. F. McIntire
W. E. Gillham H. Lee Moore
F. B. Rowley

1929

President.....Thornton Lewis
1st Vice-President.....L. A. Harding
2nd Vice-President.....W. H. Carrier
Treasurer.....W. E. Gillham
Secretary.....A. V. Hutchinson
Technical Secretary.....P. D. Close

Council

Chairman, Thornton Lewis
L. A. Harding, Vice-Chm. John Howatt
H. H. Angus W. T. Jones
W. H. Carrier E. B. Langenberg
N. W. Downes G. L. Larson
Roswell Farnham F. C. McIntosh
W. E. Gillham W. A. Rowe
C. V. Haynes A. C. Willard F. B. Rowley

1930

President.....L. A. Harding
1st Vice-President.....W. H. Carrier
2nd Vice-President.....F. B. Rowley
Treasurer.....C. W. Farrar
Secretary.....A. V. Hutchinson
Technical Secretary.....P. D. Close

Council

Chairman, L. A. Harding
W. H. Carrier, Vice-Chm. John Howatt
H. H. Angus W. T. Jones
D. S. Boyden E. B. Langenberg
R. H. Carpenter G. L. Larson
J. D. Cassell Thornton Lewis
N. W. Downes F. C. McIntosh
Roswell Farnham W. A. Rowe
C. W. Farrar F. B. Rowley

ROLL OF MEMBERSHIP

1931

President W. H. Carrier
1st Vice-President F. B. Rowley
2nd Vice-President W. T. Jones
Treasurer F. D. Mensing
Secretary A. V. Hutchinson
Technical Secretary P. D. Close

Council

Chairman, W. H. Carrier
F. B. Rowley, Vice-Chm.
 D. S. Boyden
 E. K. Campbell
 R. H. Carpenter
 J. D. Cassell
 E. O. Eastwood
 Roswell Farnham
 E. H. Gurney
 L. A. Harding
 John Howatt
 W. T. Jones
 E. B. Langenberg
 G. L. Larson
 F. C. McIntosh
 F. D. Mensing
 W. A. Rowe

1932

President F. B. Rowley
1st Vice-President W. T. Jones
2nd Vice-President C. V. Haynes
Treasurer F. D. Mensing
Secretary A. V. Hutchinson
Technical Secretary P. D. Close

Council

Chairman, F. B. Rowley
F. E. Giesecke, Vice-Chm.
 D. S. Boyden
 E. K. Campbell
 R. H. Carpenter
 W. H. Carrier
 John D. Cassell
 E. O. Eastwood
 Roswell Farnham
 F. E. Giesecke
 E. H. Gurney
 John Howatt
 C. V. Haynes
 John Howatt
 G. L. Larson
 J. F. McIntire
 F. D. Mensing
 W. E. Stark

1933

President W. T. Jones
1st Vice-President C. V. Haynes
2nd Vice-President John Howatt
Treasurer D. S. Boyden
Secretary A. V. Hutchinson

Council

Chairman, W. T. Jones
C. V. Haynes, Vice-Chm.
 D. S. Boyden
 E. K. Campbell
 R. H. Carpenter
 J. D. Cassell
 E. O. Eastwood
 Roswell Farnham
 F. E. Giesecke
 E. H. Gurney
 John Howatt
 G. L. Larson
 J. F. McIntire
 F. C. McIntosh
 L. W. Moon
 F. B. Rowley
 W. E. Stark

1934

President C. V. Haynes
1st Vice-President John Howatt
2nd Vice-President G. L. Larson
Treasurer D. S. Boyden
Secretary A. V. Hutchinson

Council

Chairman, C. V. Haynes
John Howatt, Vice-Chm.
 M. C. Beman
 D. S. Boyden
 Albert Buenger
 R. H. Carpenter
 J. D. Cassell
 F. E. Giesecke
 E. H. Gurney
 W. T. Jones
 G. L. Larson
 J. F. McIntire
 F. C. McIntosh
 L. Walter Moon
 O. W. Ott
 W. A. Russell
 W. E. Stark

1935

President John Howatt
1st Vice-President G. L. Larson
2nd Vice-President D. S. Boyden
Treasurer A. J. Offner
Secretary A. V. Hutchinson

Council

Chairman, John Howatt
G. L. Larson, Vice-Chm.
 M. C. Beman
 D. S. Boyden
 Albert Buenger
 R. H. Carpenter
 J. D. Cassell
 F. E. Giesecke
 E. H. Gurney
 C. V. Haynes
 J. F. McIntire
 F. C. McIntosh
 L. Walter Moon
 A. J. Offner
 O. W. Ott
 W. A. Russell
 W. E. Stark

1936

President G. L. Larson
1st Vice-President D. S. Boyden
2nd Vice-President E. H. Gurney
Treasurer A. J. Offner
Secretary A. V. Hutchinson

Council

Chairman, G. L. Larson
D. S. Boyden, Vice-Chm.
 M. C. Beman
 R. C. Bolsinger
 Albert Buenger
 S. H. Downs
 W. L. Fleisher
 F. E. Giesecke
 E. H. Gurney
 John Howatt
 C. M. Humphreys
 L. Walter Moon
 J. F. McIntire
 A. J. Offner
 O. W. Ott
 W. A. Russell
 W. E. Stark

1937

President D. S. Boyden
1st Vice-President E. Holt Gurney
2nd Vice-President J. F. McIntire
Treasurer A. J. Offner
Secretary A. V. Hutchinson

Council

Chairman, D. S. Boyden
E. H. Gurney, Vice-Chm.
 J. J. Aeberly
 M. C. Beman
 R. C. Bolsinger
 Albert Buenger
 S. H. Downs
 E. O. Eastwood
 W. L. Fleisher
 F. E. Giesecke
 C. M. Humphreys
 G. L. Larson
 J. F. McIntire
 A. J. Offner
 W. A. Russell

1938

President E. Holt Gurney
1st Vice-President J. F. McIntire
2nd Vice-President F. E. Giesecke
Treasurer A. J. Offner
Secretary A. V. Hutchinson
Technical Secretary John James

Council

Chairman, E. Holt Gurney
J. F. McIntire, Vice-Chm.
 N. D. Adams
 J. J. Aeberly
 M. C. Beman
 R. C. Bolsinger
 D. S. Boyden
 S. H. Downs
 E. O. Eastwood
 W. L. Fleisher
 F. E. Giesecke
 C. M. Humphreys
 A. P. Kratz
 A. J. Offner
 W. A. Russell
 J. H. Walker
 G. L. Wiggs

1939

President J. F. McIntire
1st Vice-President F. E. Giesecke
2nd Vice-President W. L. Fleisher
Treasurer M. F. Blankin
Secretary A. V. Hutchinson
Technical Secretary John James

Council

Chairman, J. F. McIntire
F. E. Giesecke, Vice-Chm.
 N. D. Adams
 J. J. Aeberly
 M. C. Beman
 M. F. Blankin
 E. K. Campbell
 S. H. Downs
 E. O. Eastwood
 W. L. Fleisher
 E. H. Gurney
 A. P. Kratz
 A. J. Offner
 W. A. Russell
 G. L. Tuve
 J. H. Walker
 G. L. Wiggs

1940

President F. E. Giesecke
1st Vice-President W. L. Fleisher
2nd Vice-President E. O. Eastwood
Treasurer M. F. Blankin
Secretary A. V. Hutchinson
Technical Secretary John James

Council

Chairman, F. E. Giesecke
W. L. Fleisher, Vice-Chm.
 N. D. Adams
 M. F. Blankin
 E. K. Campbell
 J. F. S. Collins, Jr.
 S. H. Downs
 E. O. Eastwood
 A. P. Kratz
 E. N. McDonnell
 J. F. McIntire
 A. J. Offner
 G. L. Tuve
 T. H. Urdahl
 J. H. Walker
 G. L. Wiggs
 C.-E. A. Winslow

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1941

President W. L. Fleisher
1st Vice-President E. O. Eastwood
2nd Vice-President J. H. Walker
Treasurer M. F. Blankin
Secretary A. V. Hutchinson
Technical Secretary John James

Council

Chairman, W. L. Fleisher
E. O. Eastwood, Vice-Chm. A. J. Offner
 M. F. Blankin W. A. Russell
 E. K. Campbell L. P. Saunders
 J. F. Collins, Jr. C. Tasker
 S. H. Downs G. L. Tuve
 F. E. Giesecke T. H. Urdahl
 A. P. Kratz J. H. Walker
 E. N. McDonnell C.-E. A. Winslow
 A. E. Stacey, Jr., *Ex-Officio*

1942

President E. O. Eastwood
1st Vice-President M. F. Blankin
2nd Vice-President S. H. Downs
Treasurer E. K. Campbell
Secretary A. V. Hutchinson
Technical Secretary John James

Council

Chairman, E. O. Eastwood
M. F. Blankin, Vice-Chm. A. J. Offner
 E. K. Campbell W. A. Russell
 J. F. Collins, Jr. L. P. Saunders
 S. H. Downs A. E. Stacey, Jr.
 W. L. Fleisher C. Tasker
 A. P. Kratz T. H. Urdahl
 E. N. McDonnell C.-E. A. Winslow
 L. G. Miller B. M. Woods
 F. C. McIntosh, *Ex-Officio*

